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COLLECTING MICRO-ORGANISMS FROM THE ARCTIC ATMOSPHERE

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WITH FIELD NOTES AND MATERIAL

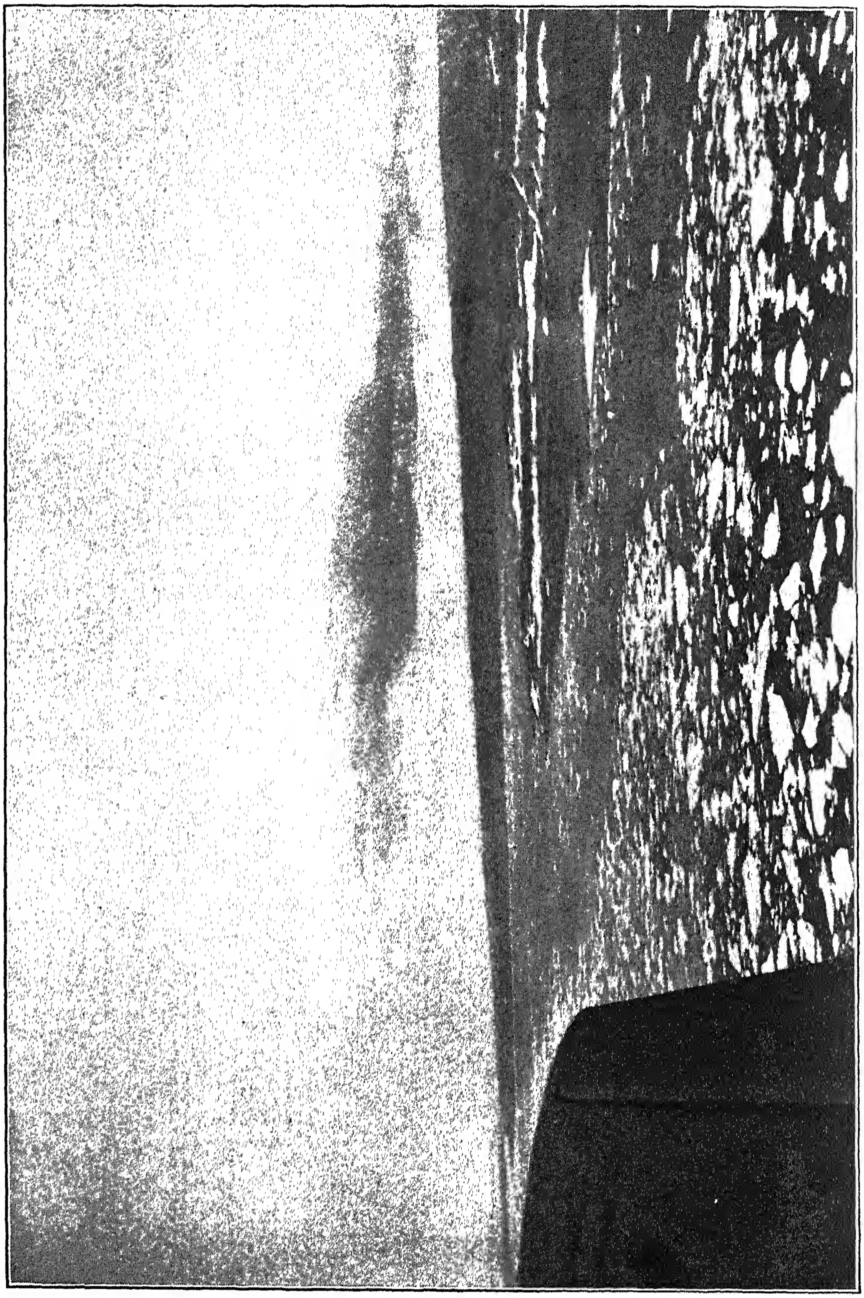
By CHARLES A. LINDBERGH

When the red-winged monoplane piloted by Charles A. Lindbergh soared away from Flushing Bay on July 9, 1933, bound for aerial exploration near the Arctic Circle, there began an unusual botanical collecting trip. Mrs. Lindbergh was prepared to fly the ship during intervals when her husband might be occupied with manipulation of an instrument new to transatlantic airplanes—so new, in fact, that it was completed just in time for the writer to carry it by plane from Washington to New York to be added to other scientific equipment which had been assembled for the expedition. With this new device, which, being untried, was noncommittally called the "sky hook," it was planned to make collections of micro-organisms from the atmosphere along the course of flight. As an incidental feature of their aerial voyage, the two flyers were cooperating with the U. S. Department of Agriculture in its studies of the epidemiology of rusts and other plant diseases. It was also hoped that identification of materials collected at various altitudes between points on the course might contribute to our knowledge of the movement of air currents in northern regions.

History of Air-Content Studies

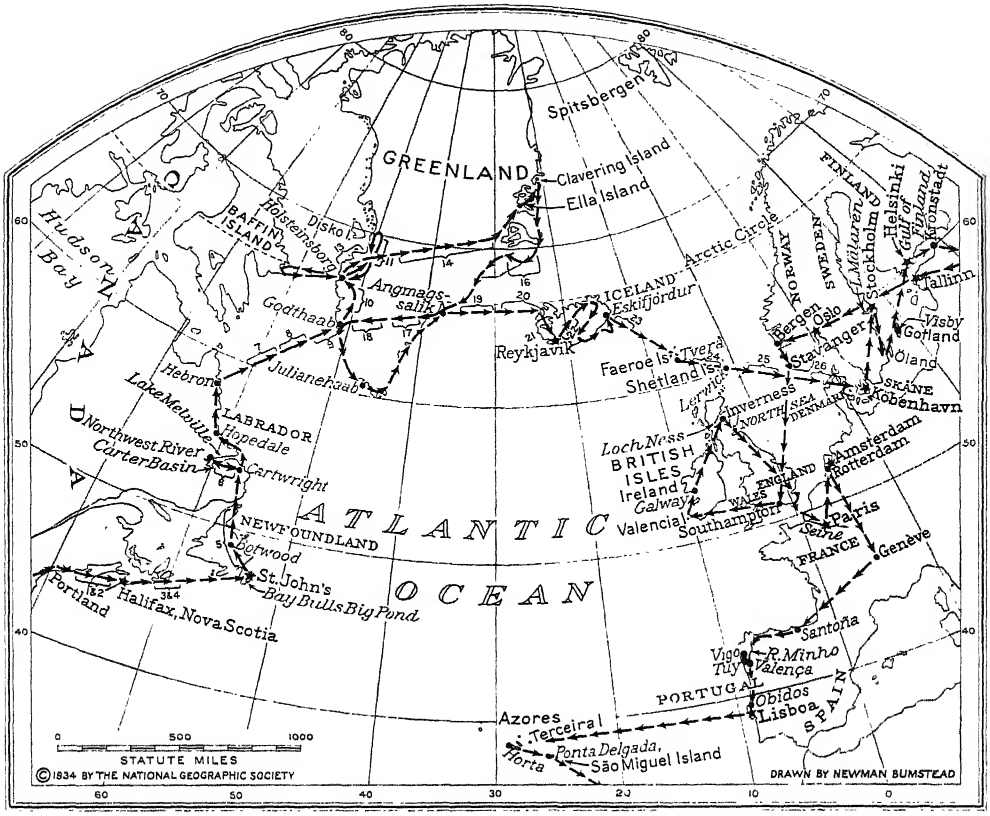
While it is generally known that bacteria, spores of higher fungi and pollen grains are present among dust particles in the atmosphere near the earth's surface, much detailed information of practical value remains to be revealed by further research. The aerial movement of pollen from certain flowering plants concerns the physician who deals with "hay fever" and related troubles. The plant pathologist and the medico pathologist are interested in obtaining facts concerning the part that air currents may play in disseminating reproductive bodies of organisms that cause specific diseases of plants and animals. Definite information of this sort is obviously an aid to a well-planned control program. As early as 1921 airplanes were used in making collections of rust spores as an aid to planning the barberry-eradication campaign for the control of stem rust of small grains. The work, by E. C. Stakman,[1] A. W. Henr[y], G. C. Curran, W. N. Christopher an[d] pilots of the Army Air Corps, in th[e] course of cooperative investigations [of] the U. S. Department of Agriculture an[d]

[1] Stakman *et al.*, *Jour. Agr. Research*, [...] 1923.



Photograph by Charles and Anne Lindbergh

FIG. 1. LOOKING WEST FROM OVER SCORESBY SOUND



Courtesy of The National Geographic Society

FIG. 2. MAP SHOWING ROUTES FLOWN AND POINTS BETWEEN WHICH COLLECTIONS WERE MADE. NUMBERS INDICATE INDIVIDUAL COLLECTIONS AND REFER TO RECORDS SOME OF WHICH ARE GIVEN IN FIGURES 8 AND 9.

the University of Minnesota, stimulated other such studies. Similar rust spore collections were later obtained by plant pathologists in Canada, Germany and Russia.

Since the microscope first came into use, studies of micro-organisms in the atmosphere have been of absorbing interest to botanists and medical men. It was in 1830 that Ehrenberg[2] first published on microscopic objects which he found present in atmospheric dust. Later he reported finding infusoria in a dust sample collected by Darwin when on board the *Beagle* near Porto Praya. Perhaps inspired by the studies of Ehrenberg, Berkeley,[3] in 1857, writes in his "Introduction to Cryptogamic Botany":

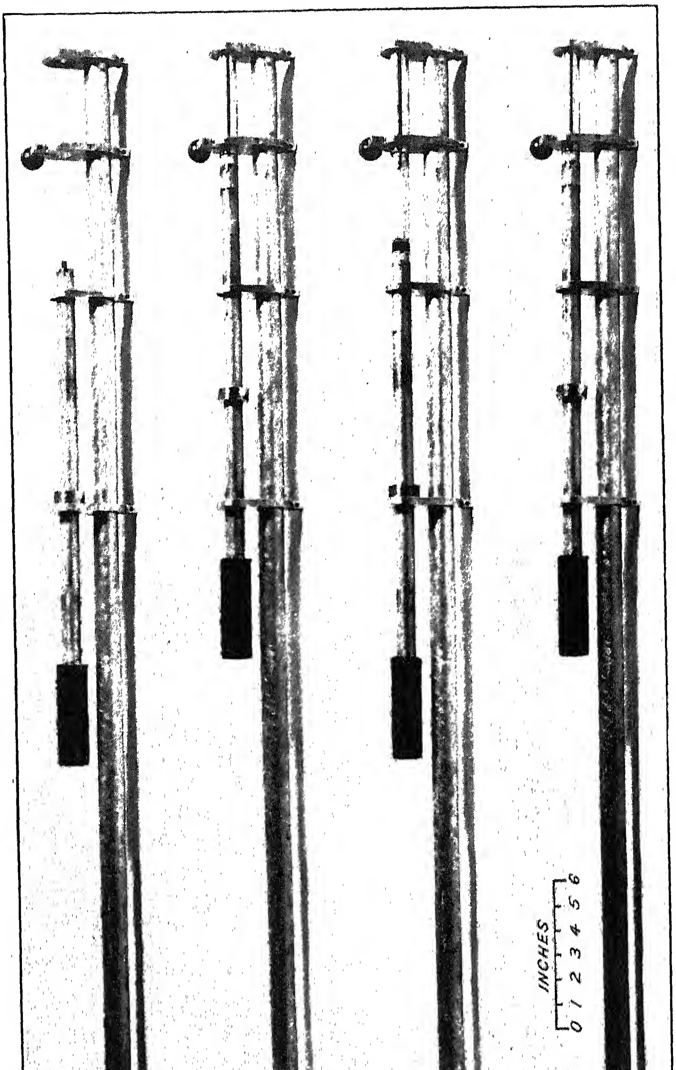
> Other spores are wafted about in the air, where they may remain for a greater or less period, till, obeying the natural laws of gravity, they descend in some distant regions. The trade winds, for instance, carry spores of Fungi mixed with their dust, which must have travelled thousands of miles before they are deposited.

Pasteur,[4] using an aspirator, conducted measured quantities of air through gun cotton, dissolved the cotton and examined the sediment with the microscope. By this means and his classical experiments involving the introduction of air from various sources into flasks of sterilized nutrient solution,

[2] Ehrenberg, *Ann. Phys. u. Chem.*, Jahrgang 1830, Viertes Stück, Vol. 17–18, pp. 477–514, 1829–30.

[3] Berkeley, "Introduction to Cryptogamic Botany," London, 1857, p. 258.

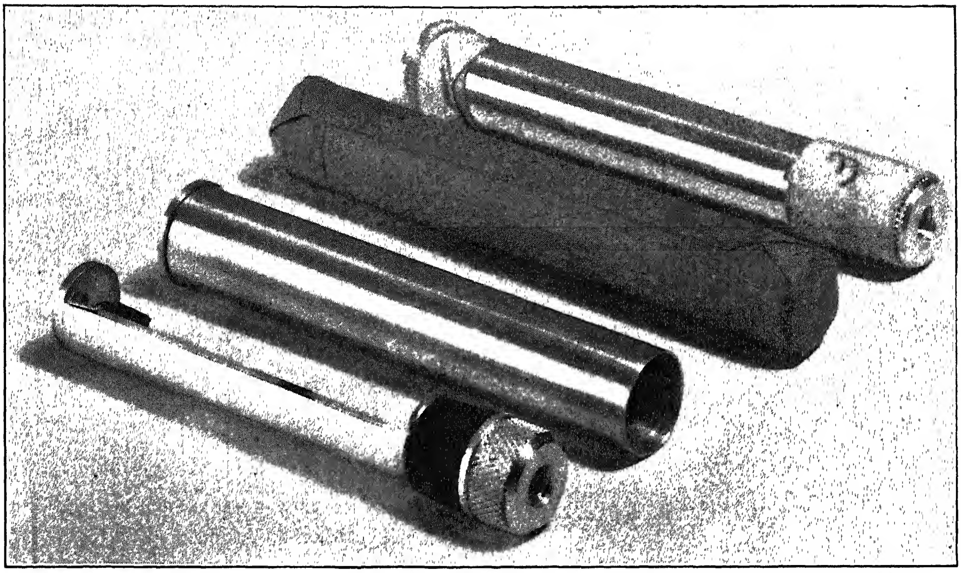
[4] Pasteur, *Compt. Rend. Acad. Sci. (Paris)*, 50, pp. 303–307, 1860.



Photograph by M. L. F. Foubert

FIG. 3. THE "SKY HOOK"

BUILT AROUND A PIECE OF ALUMINUM TUBING 1 INCH IN DIAMETER AND 42 INCHES IN LENGTH. WHEN IN USE, THE LOWER END OF THE TUBING SLIPS INTO A BRACKET PROVIDED FOR THE PURPOSE AT THE LEFT FRONT OF THE FORWARD COCKPIT. IN THIS POSITION, THE TUBING PROJECTS VERTICALLY TO A HEIGHT APPROXIMATELY 2 FEET ABOVE THE EDGE OF THE COCKPIT. THE UPPER END OF THE TUBING CARRIES TWO GUIDES INTO WHICH INTERCHANGEABLE ALUMINUM CARTRIDGES (FIG. 4) CAN BE SLIPPED AND FIRMLY FASTENED IN POSITION. AFTER THE UNEXPOSED CARTRIDGE IS ATTACHED TO THE HANDLE AND THIS IS CLAMPED INTO POSITION, THE ENTIRE OPERATION OF EXPOSING THE SLIDE AND RETURNING IT TO THE CONTAINER CAN BE CARRIED OUT BY MEANS OF AN ALUMINUM PULL-PUSH ROD OPERATED FROM BELOW, THUS AVOIDING DANGER OF CONTAMINATION FROM HANDS AND CLOTHING. ILLUSTRATION SHOWS: A, HANDLE READY TO RECEIVE CARTRIDGE; B, CARTRIDGE INSERTED AND READY TO BE PROJECTED INTO AIR STREAM; C, SLIDE PULLED INTO EXPOSURE POSITION; D, SLIDE RETURNED TO CYLINDER AFTER WHICH CARTRIDGE IS REMOVED AND SEALED.



Photograph by M. L. F. Foubert

FIG. 4. EACH SLIDE CONTAINER OR CARTRIDGE CONSISTS OF TWO MAJOR PIECES

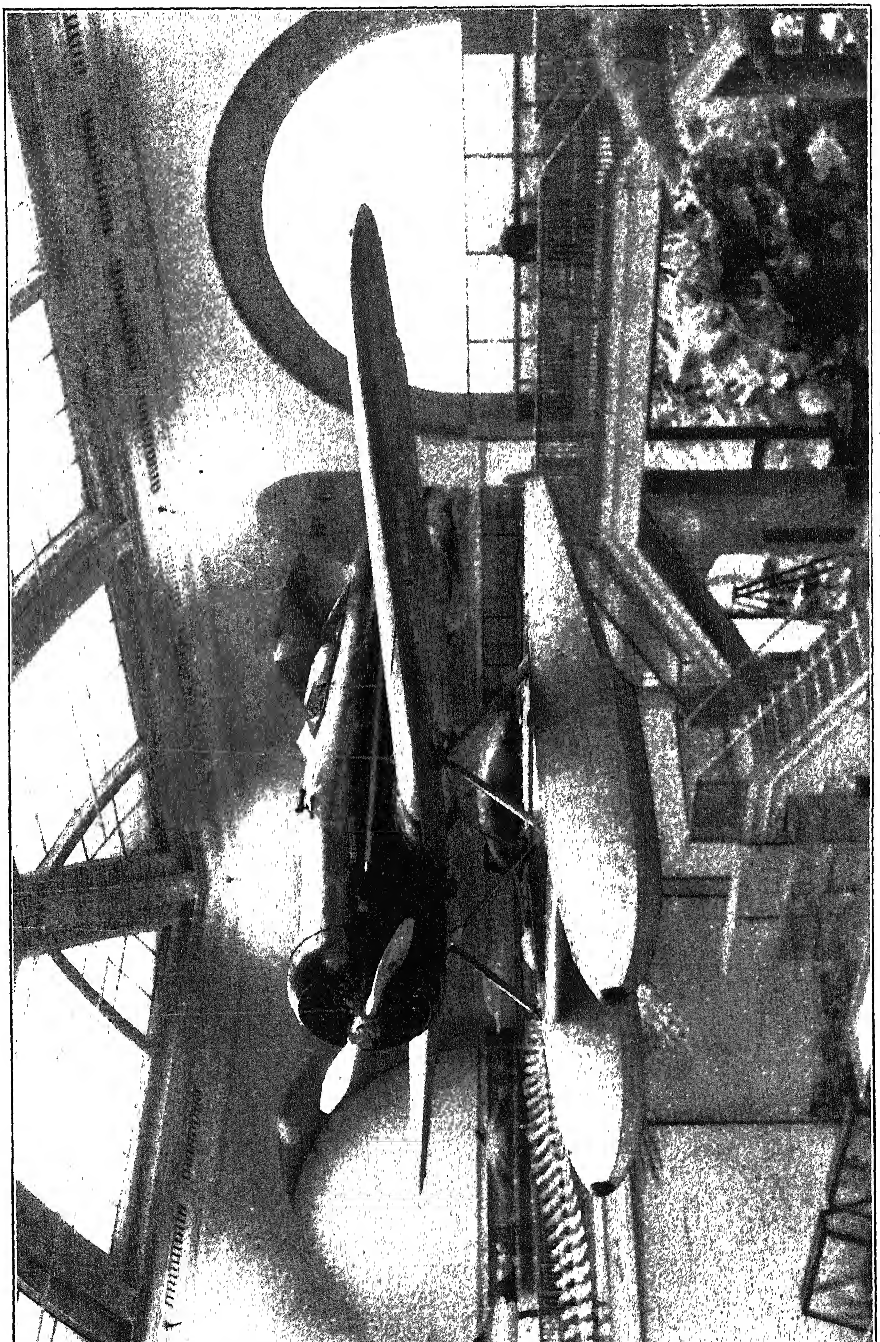
ONE OF THESE IS AN OUTER SHELL MADE FROM A SECTION OF THIN-WALLED ALUMINUM TUBING 4⅛″ LONG AND 11/16″ INSIDE DIAMETER THAT IS PERMANENTLY SEALED AT ONE END AND OPEN AT THE OTHER. THE SECOND PART IS AN ALUMINUM ROD THAT IS CUT AWAY TO FORM A FLAT SURFACE THE LENGTH OF THE GLASS SLIDE. THE SLIDE IS FIRMLY ATTACHED TO THIS FLAT SURFACE BY MEANS OF A SCREW DEVICE. THIS INNER ALUMINUM BAR TERMINATES IN A CAP PIECE PROVIDED WITH A SEAL MADE OF A SHORT SECTION OF GUM-RUBBER TUBING HELD IN POSITION BY MACHINED POINTS. WHEN THE SLIDE IS IN THE CYLINDER, THE GUM RUBBER PROVIDES A SUFFICIENTLY TIGHT-FITTING CONNECTION TO PREVENT CONTAMINATION FROM THE OUTSIDE. WHEN THE BAR AND MOUNTED SLIDE HAVE BEEN WITHDRAWN TO THE EXPOSURE POSITION WITH THE PETROLATUM-COATED SURFACE FACING THE AIR STREAM, A CHECK RING ON THE CONTROL ROD STOPS THE WITHDRAWAL AT A POINT THAT LEAVES THE UPPER END OF THE SLIDE BAR SUPPORTED AGAINST THE LOWER RIM OF THE CYLINDRICAL CONTAINER. THE ILLUSTRATION SHOWS A SLIDE CARRYING BAR BEFORE BEING PLACED IN THE ADJACENT CYLINDER. BESIDE THESE IS A LOADED, PAPER-WRAPPED CYLINDER WHICH WAS CARRIED ON THE TRIP AND RETURNED UNUSED. AT THE EXTREME RIGHT IS AN EXPOSED CARTRIDGE AS RETURNED TO THE LABORATORY. IMMEDIATELY AFTER EXPOSURE THE CARTRIDGE WAS SEALED WITH ADHESIVE TAPE AND THE COLLECTION NUMBER WAS RECORDED. TAPE WAS APPLIED AT THE TOP TO PREVENT A POSSIBLE BREAKING AWAY OF THE CAP PIECE. THIS, HOWEVER, IN NO INSTANCE OCCURRED.

he proved that there are living bacteria and mold spores in the air and that the numbers vary considerably in different locations.

The many studies of air content conducted by nineteenth-century medical men in their efforts to combat epidemics of cholera and other diseases are reviewed by Cunningham[5] in a paper reporting his studies of air pollution, written while he served with the British Government as surgeon in India. Publication of this paper in 1873 stimulated bacteriologists in their studies of organisms present in the air around them.

Advances made in the development of aircraft early in the twentieth century made it possible to extend the scope of such investigations. All the earlier work was based on examination of air as

[5] Cunningham, "Microscopic Examinations of Air," Calcutta, 1873.



Courtesy of The American Museum of Natural History

FIG. 5. *TINGMISSARTOQ*

IN THE HALL OF OCEAN LIFE, THE AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY. HERE THE SHIP IS SURROUNDED BY NUMEROUS INTERESTING EXHIBITS FROM THE LINDBERGH ATLANTIC SURVEY FLIGHT.

found near the surface of the earth. Although Pasteur considered the possibility of conducting experiments from a hot-air balloon, he decided that the method presented too many difficulties, so carried his flasks up the Jura Mountains and the Montan Verte, where exposures were made at 850 and 2,000 meters above sea level. The previously mentioned studies of rust-spore movement by use of spore traps on airplanes suggested new possibilities for study of dissemination of organisms that cause plant diseases.

For example, the writer[6] has obtained pure cultures of numerous fungi from spores which he collected during training flights of the naval airship *Los Angeles* in January and April, 1932, and from airplanes in the course of investigations begun in 1931 by the U. S. Department of Agriculture with the cooperation of the Navy, Army and Coast Guard air-service units. The ease with which vigorous cultures of fungi have been grown from spores collected during these airplane flights, which were made at various altitudes over widely scattered coastal, desert, mountain, forest and agricultural areas of the United States, emphasizes the probability of long-distance movement of viable spores of certain saprophytic and parasitic organisms.

The day-by-day situation with regard to presence of micro-organisms at different levels in the atmosphere over a given territory was discussed by Proctor[7] before the American Academy of Arts and Sciences in April, 1934. In his summary of studies of 201 separate collections secured from 45 airplane flights made over Boston by the Meteorology Division of the Department of Aeronautical Engineering, Massachusetts Institute of Technology, he states: "Bacteria and molds were found above 19,600 feet, yeasts and pollens were found above 16,000 feet."

Significance of Northern Collections

Although, prior to the Lindbergh Atlantic Survey Flight, several investigators have used airplanes as an aid to study of micro-organisms present in air currents, such collections from the upper air have always been made over or near land in latitudes where numerous species of fungi growing on abundant local vegetation were constantly liberating spores. The opportunities for obtaining significant data on long-distance movements of spores and pollen would seem particularly good in the case of exposures made over water and ice of northern latitudes as compared with similar studies over land in the temperate zone, where the collector may be confused by much material originating from local sources (Fig. 1). The suitability of the course covered by *Tingmissartoq* in 1933 for studies of this kind is evident from the photographs and excellent descriptions given in Mrs. Lindbergh's[8] story of the flight and from the route as indicated on the map (Fig. 2).

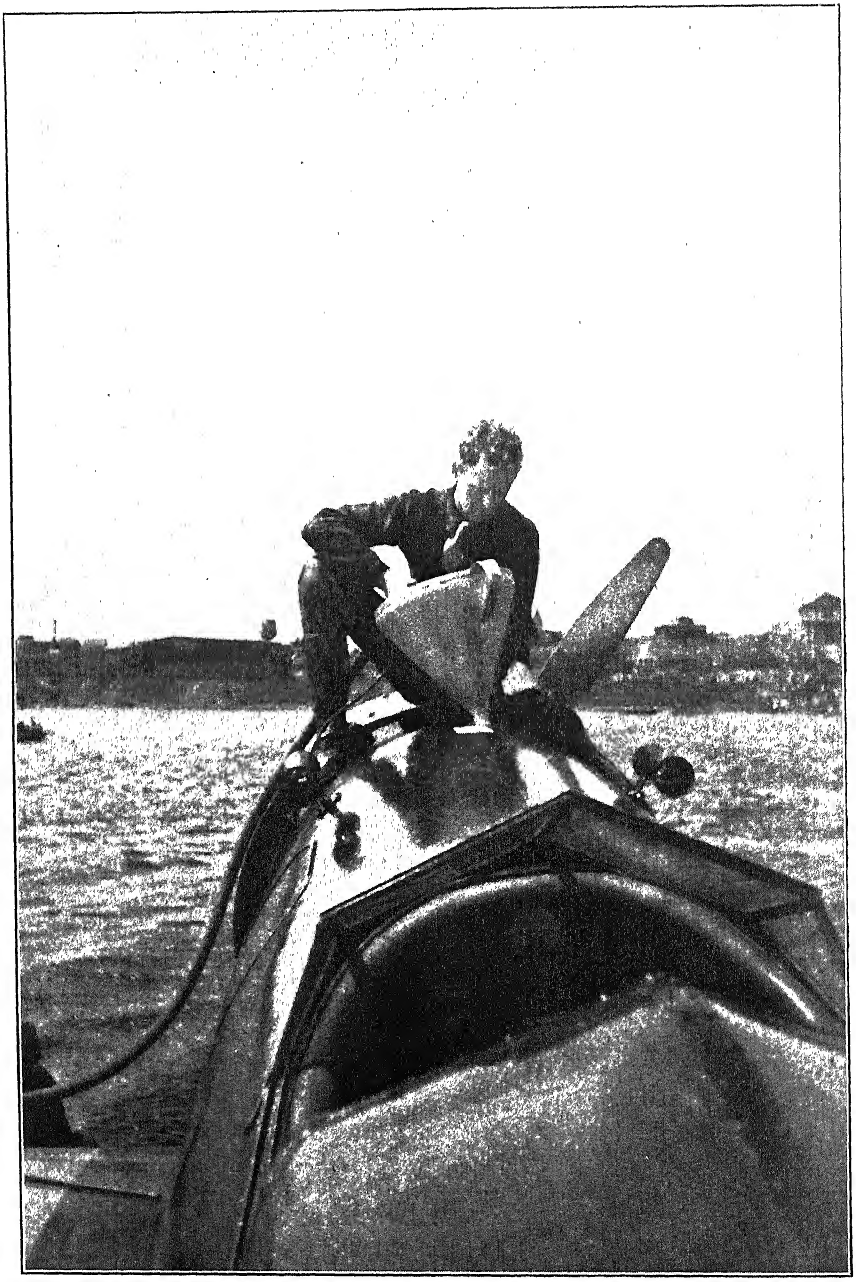
The "Sky Hook"

The collecting device for this particular trip was designed by Colonel Lindbergh (Figs. 3 and 4) with several requirements in mind. It should be compact, light in weight and simple to operate. The containers enclosing the collecting medium must be constructed to prevent contamination before or after exposure. They must be sufficiently

[6] Meier *et al.*, *Phytopathology*, 23, 1933.

[7] Proctor, *Proc. Amer. Acad. Arts and Sci.*, Vol. 69, No. 8, Aug., 1934 (Contrib. Dept. Biol. and Public Health, Mass. Inst. Technol., No. 29.)

[8] Lindbergh, Anne Morrow. Foreword by Charles A. Lindbergh, *Nat. Geog. Mag.*, 66, pp. 259–337, 1934. In this story, Mrs. Lindbergh tells of the christening of the plane: " 'Tingmissartoq!' Eskimos shouted when the monoplane circled overhead. So *Tingmissartoq* it became—'The one who flies like a big bird.' "



Photograph by Charles and Anne Lindbergh

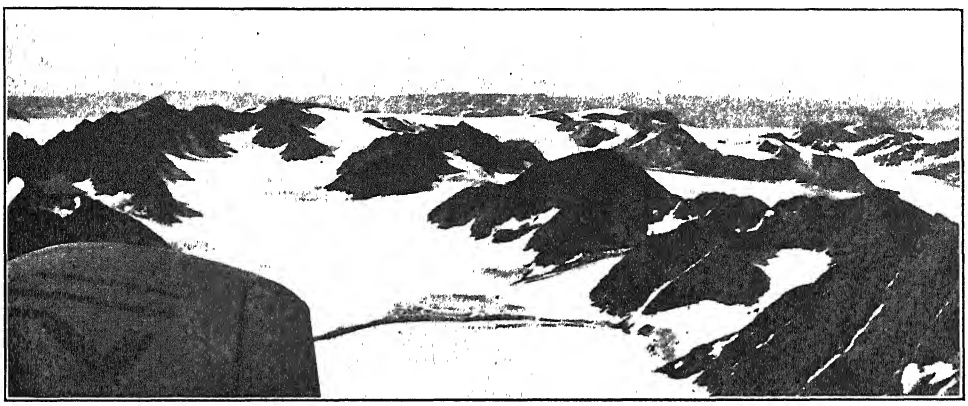
FIG. 6. REFUELING AT BOTWOOD, NEWFOUNDLAND

strong to stand possible rough handling without breakage. It was, of course, also important that the collecting medium used be such that material would remain in condition for examination some weeks or months after the sample was taken. Colonel Lindbergh's knowledge of pure-culture technique made him thoroughly aware of the necessity of developing a trap that could be used with minimum danger of error resulting from contact with dust in the cockpit. From discussion of these various requirements a plan was evolved for a modification of the oiled microscope slide trap. Glass slides with oiled surfaces have frequently been utilized in aeroscopes by investigators working on the ground, from roofs of buildings or from aircraft. After a design had been developed, the services of the American Instrument Company, of Washington, D. C., were enlisted. The personal interest taken in the project by both officers and employees of this company made possible "overnight" construction of the "Sky Hook" and fifty cartridges.

In preparation for these northern flights, the cartridges or slide containers (Fig. 4), after having been thoroughly cleaned, were loaded in the still air of a culture room. After a mount carrying the petrolatum-coated glass slide had been inserted in each cylinder, with the gum rubber washer serving as a seal, a band of adhesive tape was applied. This served to prevent accidental opening. The surface of the entire cartridge and seal was then cleaned by moistening with alcohol, followed by thorough rubbing with sterile gauze, after which the cartridge was wrapped in clean sterile paper for protection until used.

Contamination from the Airplane Unlikely

The low-winged monoplane *Tingmissartoq* is an exceedingly trim ship, as is evident to those who have viewed her graceful lines as she hangs suspended, a central figure of the Lindbergh collection in the American Museum of Natural History (Fig. 5). Immediately forward and below the cockpit windshield is nothing but the smooth skin of the fuselage. The exhaust is carried away from the motor through a short stack below the fuselage. Directly ahead of the spore trap when in exposure position were the propeller tips only. In view of the fact that the writer frequently has found it possible to



Photograph by Charles and Anne Lindbergh. Used by special permission. Copyright, National Geographic Magazine

FIG. 7. BLACK MOUNTAINS PUSH JAGGED POINTS THROUGH THE SNOW

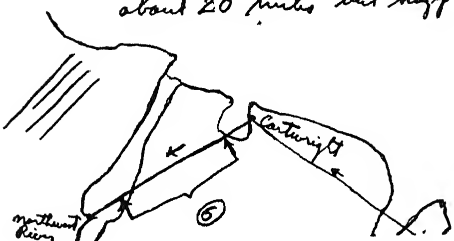
A TIP OF THE WING SHOWS IN THE PICTURE AS THE PLANE SKIRTS THE ICE CAP SOUTHWARD FROM CLAVERING ISLAND TO ANGMAGSSALIK.

11

Azimuths are given in degrees from true north and indicate direction from which wind comes

No. 5 – Will supply data later.

No. 6 – July 17 – 3:37 to 4:47 (Local time). Wind (from) 245° (true) about 10 m.p.h. Average altitude 4000 ft (2000 to 5500) Temp +12°C Air speed 115 m.p.h. Sky 7/10 to 10/10 overcast at about 8000 ft. Visibility about 20 miles but hazy.



No. 7 July 22. 17:24 G.M.T. to 18:24. Wind 270° about 15 miles. Average alt. – 2500 ft. Temp. +12°C Air speed 110, Flying over low fog. (Top about 1000 ft.) Clear above fog. ——, visibility about 100 miles. Apparently no rain for several days.

No. 8. July 22. 18:42 G.M.T. to 19:27. Wind 270° about 20 miles. Average alt. – 3000 ft. Temp +11°C. Air speed 110. Flying over low fog (Top about 1000 ft.). Clear and unlimited above fog.

No. 9 July 22. – 19:45 to 20:45 Wind 270° about 15 m.p.h. Average alt. 3000 ft. Temp. +11°C Air speed 110. No fog. Clear and unlimited.

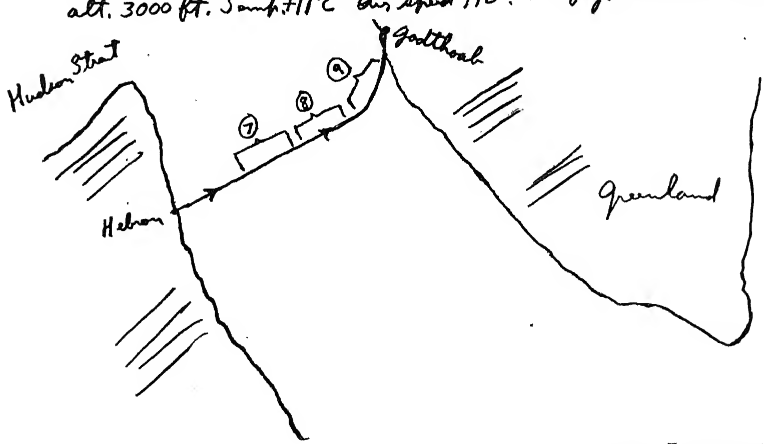


FIG. 8. PHOTOGRAPH OF ORIGINAL PENCIL NOTES SENT IN BY COLONEL LINDBERGH WITH THE SLIDE CONTAINERS. SIMILAR FREE-HAND MAPS WERE PROVIDED FOR EACH SLIDE DESCRIPTION.

No. (13) Aug 4, 1933 – 15:36 to 16:21 G.M.T. Wind 90° about 5 miles. Average alt = 5000 ft. – Temp. = 0°C. Air speed 110 miles Sky 8/10 overcast at 10,000 ft. Visibility unlimited. Lowest alt. = 4500.

No. (14) (Cotton) Aug 4, 1933 – 17:11 to 20:18 G.M.T. – Wind 180° about 40 miles at start of exposure. No wind at end of exposure. – Maximum alt = 12,500 ft. average = 10,000 Temp. minimum = –12°C, average = –9°C. Air Speed 110 miles Completely overcast at 10,000 to 15,000 ft. (Due to the comparatively low temperature the rubber cork came out while the cylinder was being removed and the lower part of the slide was exposed in the cockpit for a fraction of a second. This may be sufficient to cause an erroneous positive result)

No. (15) Aug 6, 1933 – 12:55 G.M.T. to 13:40. Wind calm except in fjords. Average alt. – 3000 ft. – Temp. = +6°C. Air sp. 115 miles. Sky clear and unlimited visibility.

No (16) Aug. 6 – 14:40 to 15:40. Wind calm. Sky clear and unlimited visibility. Average alt 7000 ft. Temp. = –1°C. Air speed 110 miles

No (17) Aug 8 – 16:22 to 17:22. Wind 45° 15 miles (From balloon observation) Sky less than 1/10 overcast (cirrus) visibility unlimited. Average alt. 8000 ft Av. temp = –8°C. Last 20 minutes completely overcast at 9000 ft (Plane flying below clouds wind shifted to North West about 20 miles.

FIG. 9. PHOTOGRAPH FROM ORIGINAL PENCIL NOTES SENT IN BY COLONEL LINDBERGH WITH THE SLIDE CONTAINERS. NUMBERS REFER TO EXPOSURES INDICATED ON THE MAP (FIG. 2).

secure clean slides during exposures at high altitudes, made by projecting the collecting device over the side of the rear cockpit of a biplane with the many surfaces ahead to collect dust when the plane is on the ground, it is evident that the rush of air when in flight quickly and thoroughly removes dust particles from these surfaces.

This particular ship had no such surfaces ahead. Being a seaplane, refueling was carried on under conditions relatively free from dust stirred up by surface winds (Fig. 6). Moreover, the speed of flight and consequent effectiveness of air washing were greater by 30 m.p.h. than those obtained in biplanes ordinarily used by the writer.

Twenty-Six Slides Exposed

Twenty-six collections were made during the period from July 11 to August 26 on flights between North Haven, Maine, and Copenhagen, Denmark. Many of these were obtained while flying over vast expanses of water, ice and bleak mountainous country (Fig. 7). With the expectation that the atmosphere of the far north would be thinly populated with organisms, if any at all were present, long exposures, thirty minutes to sixty minutes, were made. In previous work in southern latitudes exposures of three to ten minutes at air speeds ranging from eighty to one hundred eighty miles per hour have been found by the writer to give good results. The territory covered is indicated on the map shown in Fig. 2. Field notes by Colonel Lindbergh, similar to those shown in Figs. 8, 9 and 10, give circumstances surrounding each collection, making possible interpretation of results. It must be remembered, however, that frequently several days intervened between collections. During these periods the botanical relationships were, of course, changing as the season advanced. Wind direction and velocities varied at times when different collections were made. Moreover, unknown air movements and atmospheric changes were taking place between collections. These factors must all be considered in attempts at correlating results.

In an account of the work sent from Reykjavik Colonel Lindbergh wrote:

> Before opening for exposure, all the cylinders were left in the air stream from three to five minutes. They were all closed while still in position and were sealed with adhesive tape without again being opened. It was not possible, however, to avoid sometimes touching the knurled end, and the tape, of course, was exposed to the turbulent air in the cockpit.

Hence, at his suggestion, before the slides were removed for laboratory examination, the exterior of the cylinders, including the area covered by the tape, was flamed to destroy any microscopic objects which might have adhered.

Examination of Slides

Following their return to Washington, the cartridges were left unopened until each slide could be studied. In preparation for examination, the cylinder was flamed, the slide was removed in the still air of a culture chamber, and a permanent mount was made. This was done by adding a small quantity of filtered lactophenol to the exposed surface, covering the preparation with a flamed clean strip of No. 1 cover glass, and, finally, after the preparation had been allowed to rest several days in a desiccator, sealing it with lanolin cement. Counts were then made over a five square centimeter area while traversing the slide laterally with a three millimeter dry objective and 15x ocular, and photographs were taken of distinctive spores or pollen grains with this same lens combination. In some instances the camera lucida was employed for the work of recording. The position of different objects was recorded on the mechanical stage, and descriptive notes, including ocular micrometer measurements, were made of distinctive types.

Check Slides

Six slide containers, returned unused after having been carried throughout the trip, were employed as checks. Careful microscopic examination of the slides within demonstrated these to be free from spores and pollen grains.

Numerous examinations of petrolatum from the lot used in preparing the slides for the trip, likewise gave confidence in results obtained.

Discussion of Results

In these collections are found spores of fungi, pollen grains and fragments of

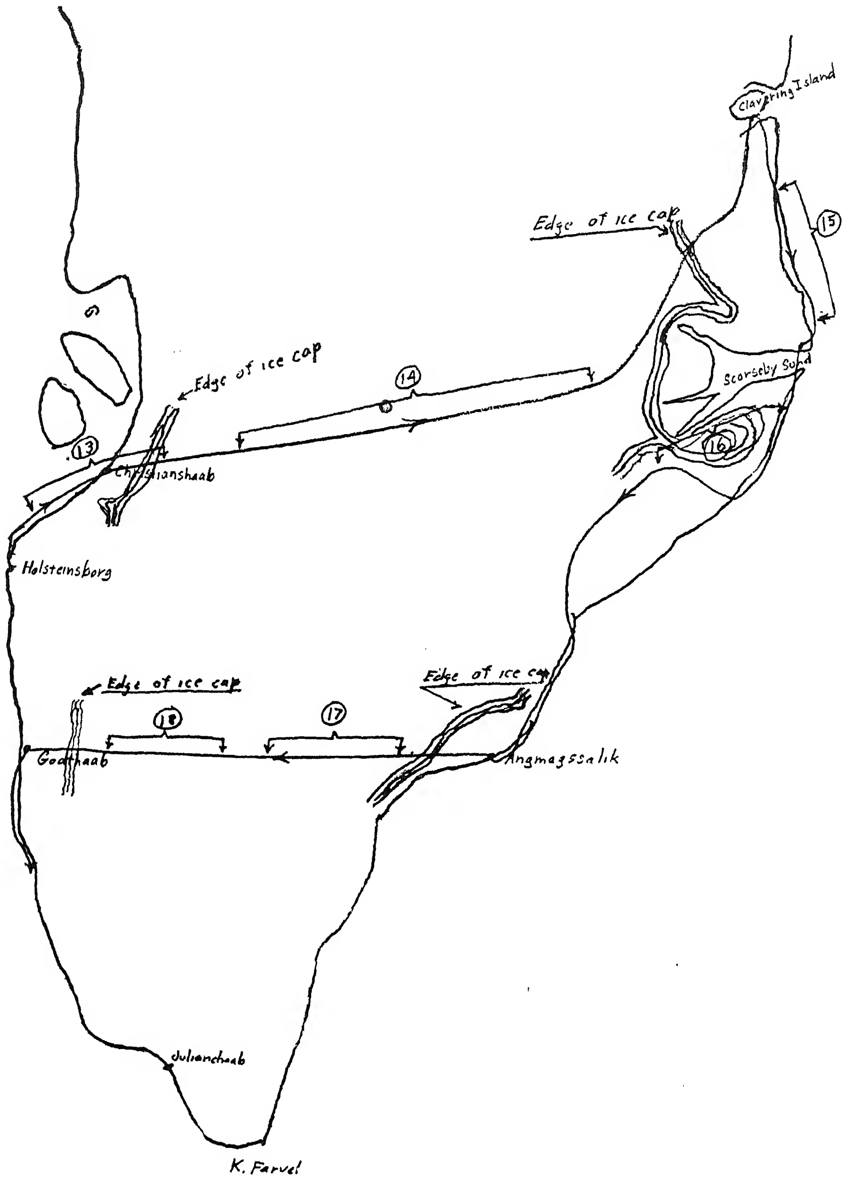
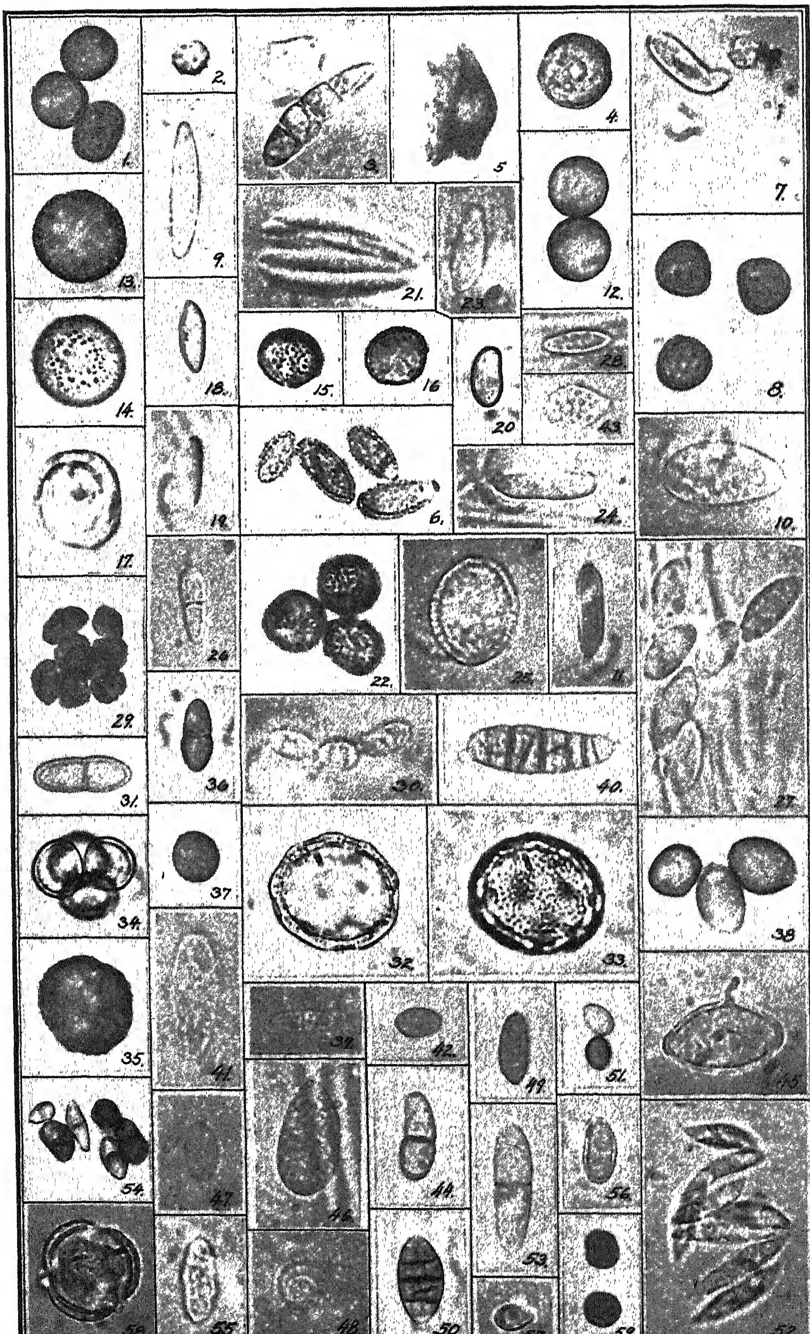


FIG. 10. ROUTE MAPS DRAWN IN THE FIELD BY COLONEL LINDBERGH SERVED TO MARK POINTS BETWEEN WHICH COLLECTIONS WERE MADE.

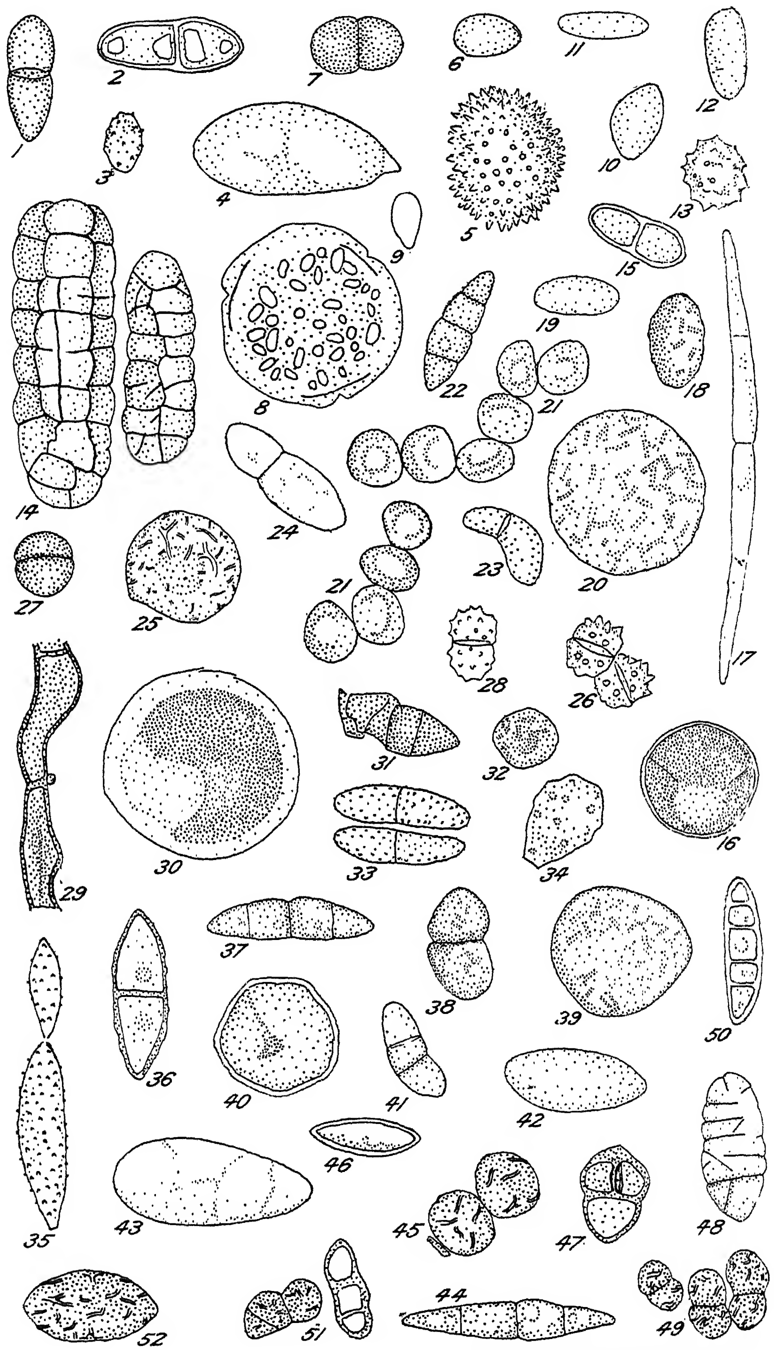
fungous hyphae. In some instances the asci of certain fungi, apparently carried up just before discharge of spores, were caught, the spores being spattered about by the impact. In addition were found unicellular algae, fragments of filamentous algae and insect wings, diatoms, objects tentatively identified as sponge spicules, volcanic ash and glass, and other microscopic débris of the air.

It is not the purpose of this paper to give detailed descriptions of the fungous spores caught. Instead, descriptions, tentative identifications and correlation of information obtained from different slides are reserved for a later paper. The two figures 11 and 12 will, however, serve to give an idea of the variety of material collected over Davis Strait and Northeastern Greenland.



Photomicrographs by F. C. Meier

FIG. 11. SOME OF THE MORE CONSPICUOUS OBJECTS FOUND ON SLIDE 9. X 660. (SEE FIGS. 2 AND 8.)



From camera-lucida drawings by F. C. Meier

FIG. 12. TYPES OF OBJECTS TRAPPED ABOVE THE ARCTIC CIRCLE ON SLIDE 15. X 970. (SEE FIGS. 2 AND 9.)

Fig. 12 is the result of a careful examination of five square centimeters surface of slide 15. This slide was exposed on August 6 for forty minutes at an average altitude of 3,000 feet above sea level over the coast of Greenland between Scoresby Sound and Clavering Island, north of 70 degrees latitude and well above the Arctic Circle. Wind was from the west, about 15 m.p.h. The complete data for this exposure are given in Figures 9 and 10. Fifty-three different types of objects were found on this slide, duplication of some bringing the total number up to one hundred and ninety-three. A similar area on slide 9, exposed over Davis Strait sixteen days earlier than slide 15, was found to contain approximately 70 different objects and a total of 238 (Fig. 11). This slide was exposed for 1 hour on July 22 at an average altitude of 3,000 feet as the plane approached Godthaab, Greenland. Wind was from the west about 15 m.p.h. (Fig. 8). Nearest land to windward was Labrador.

Critical study of such slides must obviously be limited to objects that have sufficient size and character to make possible their identification. Often in the case of fungous spores, it is impossible to establish identity. In other instances, one can at least feel sure of the genus. Often the presence of a bit of mycelium or relationship of similar spores on the slide gives a clue. Plant pathologists, mycologists and other botanists acquainted with pollens will recognize certain familiar types among those shown on Figures 11 and 12. Among the spores on those two slides are forms which have been tentatively assigned to various genera, among them being Macrosporium, Cladosporium, Leptosphaeria, Mycosphaerella, Trichothecium, Helicosporium, Uromyces, Camarosporium and Venturia. It is hoped that with the aid of specialists on different groups of fungi, lichens, mosses and flowering plants the number of positive identifications may be increased.

Writing in *Mycologia* early in 1934, Jakob E. Lange[9] says:

> But stronger and more lasting than any other impression is the evidence of the wonderful cosmopolitanism of the Agarics. When you have once found, in a Danish Sphagnum-bog, a few specimens of the "new" species *Stropharia psathyroides* Lange, it gives you a shock to meet with the very same plant in a bog in Oregon, near the Pacific Coast—and only an hour later to come upon *Lepiota cygnea* Lange, of which the only known specimens were hitherto those gathered in 1925, a few miles from my Danish home!
>
> Who can trace the aerial course of the spore?

This Lindbergh collection of micro-organisms from the atmosphere is the first of its kind to give concrete evidence of the part played by air currents in distribution of fungi between northern lands. The slides show certain spore types to be abundant over Maine and Labrador and present in diminishing numbers as collections progressed to leeward over Davis Strait, the great ice cap of Greenland and Denmark Strait. Some of the spores of fungi caught at different points show definite evidence of having been alive when trapped, for they started to send out germ tubes in the unfavorable petrolatum medium. While, as would be expected, the collections show this northern air to be more thinly populated with micro-organisms than that over the continents in more temperate regions, it must be realized that, when one viable spore is precipitated to water or vegetation under surroundings capable of sustaining growth, reproduction may be very rapid. The potentialities of world-wide distribution of spores of fungi and other organisms caught up and carried abroad by transcontinental winds may be of tremendous economic consequence.

[9] Lange, *Mycologia*, 226, pp. 1–12, 1934.

WHEN WILL LASSEN PEAK AGAIN ERUPT?

By ARTHUR HOLMES

PARK RANGER, NATIONAL PARK SERVICE, U. S. DEPARTMENT OF THE INTERIOR

IN one sentence, the year 1980 is given as the probable date that Lassen Peak, the most recently active volcano in continental United States, will again burst into action. Nature works in a mysterious way, albeit according to laws as yet little known by man, and to attempt to set a definite date on which this volcanic region will again speak in tongues of fire is at best somewhat presumptuous for mere man.

However, this prediction is based upon scientific observation. It is from Japan that there comes an inkling of the ways of volcanoes and what may be expected from them. The late Dr. Omori, professor of seismology at the Imperial University of Tokyo, after years of study found that many Pacific volcanoes erupt in definite periods of 130 years, with less frequent occurrences at half periods, or 65 years. According to R. H. Finch, U. S. Geological Survey volcanologist, Kilauea Volcano in Hawaii National Park is one of the volcanoes that has been found to definitely follow this 130- and 65-year period.

Lassen Peak, in Lassen Volcanic National Park, California, was last in eruption during the years from 1914 to 1917. The climax of these eruptions occurred in 1915. Let us add 65 years to 1915. The resulting date, 1980, is likely to witness the approximate time of the next outburst, if the periodicity of eruptions noted above is applicable here.

But 1980 is a long way off, and most of us need have no worries for what that date will hold. So let us go back a bit. Can these findings of Dr. Omori be checked in any way in their relation to the Lassen country?

If 65 years were subtracted from Lassen's last eruptions, the climax of which occurred in 1915, the resulting date would be the year 1850. That year saw the dawn of California history. Settlers were moving into the great Sacramento valley, some 50 miles west of Lassen. Indians inhabited the mountains. And behold, both Indians and white settlers report that the skies were lit up with a brilliant red glow and remained so for many nights. Some miners traveling through the Lassen country report hot lava and volcanic activity in the winter of 1850–1851. The geologist Harkness[1] reliably sets the date of the last eruption and lava flow from the remarkable Cinder Cone, only 10 miles from Lassen Peak, as the winter of 1850–1851.

There is reason to believe that about 130 years earlier the mighty Chaos Crags were literally pushed up to their present height of over 1,800 feet. These crags, symbolic of all that the name implies, are directly north, and connected with, Lassen Peak. In fact, they were pushed up to such a height that the tops crumbled over and avalanched down to form the Chaos Jumbles, across which the scenic Lassen Peak Loop crosses.

J. S. Diller, one of the pioneer geologists of the Geological Survey in 1915, concluded that the Chaos Crags might have been formed about 200 years ago, an estimate that has since been corroborated on the evidence of vegetation by Professor Howell Williams, of the University of California.[2]

An outburst did occur exactly 65 years ago, and another 200 years ago, which are within the periods given by Dr. Omori. While these eruptions occurred not on Lassen Peak itself, the

[1] H. A. Harkness, "A Recent Volcano in Plumas County," *Proc. Calif. Acad. Sci.*, Vol. 5, pp. 408–412, 1874.

[2] H. Williams, "Geology of the Lassen Volcanic National Park, California," *Bull. Dept. of Geol. Sci.*, Univ. of Calif., Vol. 21, No. 8, p. 347.

source, nevertheless, was the same. It adds to the fascination of the region *not* to know exactly where to look for the next outburst of volcanic activity.

All of which is an interesting speculation, but it gives the park rangers in Lassen Volcanic National Park some basis upon which to answer the daily inquiries by park visitors, "Is there any chance of Lassen erupting while I am here?" "When will it erupt again?" "Can I climb up and look into the crater?" and similar questions.

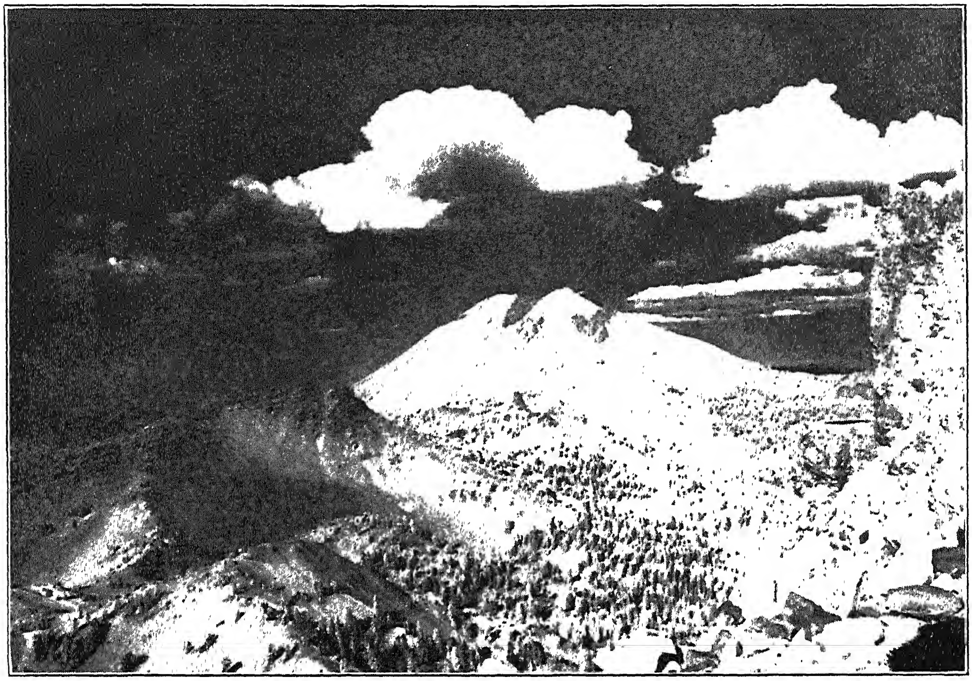
Lassen Volcanic National Park in Northern California was set aside by Act of Congress in 1916 to protect but at the same time make accessible to the public Lassen Peak, the Cinder Cone, Chaos Crags and the wealth of other intensely interesting volcanic, glacial, scenic and recreational features found here in such abundance. The park is administered by the National Park Service through the local park superintendent. A corps of park rangers, naturalists and engineers assist the superintendent in his work.

Lassen Peak is naturally the central point of interest. It startled the world by bursting into eruption in 1914, after having been considered entirely inactive. In fact, the U. S. Forest Service first used Lassen Peak as a fire lookout station in 1912. Needless to say, the building was blown to bits, although no one was injured, because the eruption

Photograph by Chester Mullen

A DOUBLE ERUPTION OF LASSEN PEAK,

AS SEEN FROM THE TIMBERED SHORES OF REFLECTION LAKE, IN LASSEN VOLCANIC NATIONAL PARK. THE UPPER CLOUD IS FROM A BURST OF SMOKE AND STEAM, AND BEFORE IT BLOWS AWAY ANOTHER OUTBURST CAN BE SEEN RISING FROM THE CRATER OF LASSEN PEAK. TAKEN OCT. 6, 1915.



LASSEN PEAK[1]

THE MOST RECENTLY ACTIVE VOLCANIC MOUNTAIN IN CONTINENTAL U. S., AS SEEN FROM BROKEOFF MOUNTAIN. THE TONGUE OF LAVA WHICH FLOWED OUT DURING THE 1915 ERUPTIONS CAN BE SEEN EXTENDING DOWN FROM THE FLAT TOP OF THE PEAK. THE DARK SKY AND LIGHT-COLORED TREES ARE DUE TO THE PECULIARITIES OF THE PHOTOGRAPHIC PLATE. AN INFRA-RED NEGATIVE WAS USED, WHICH HAS THE UNCANNY PROPERTIES OF PENETRATING HAZE TO DISTANCES THAT CAN NOT BE SEEN WITH THE HUMAN EYE.

occurred early in the season (May 30) before any one was stationed there. Likewise, needless to say, the government has never considered it exactly prudent to replace the lookout station.

In 1915 two major eruptions resulted in the devastation of a large area on the north side of Lassen Peak. The park highway crosses the path of the flood and gas blast, and visitors find the section one of the most interesting and spectacular in the park. At this same time, May, 1915, molten lava welled up in the vent and filled the crater so that to-day Lassen Peak is comparatively flat-topped.

Following the outburst of 1915, dozens of eruptions took place at frequent intervals, but with decreasing intensity, until 1917, when the last authentic eruption was recorded. Officially, Lassen Peak is the most recently active volcano in the continental United States, which excludes the active volcanoes in Alaska and Hawaii.

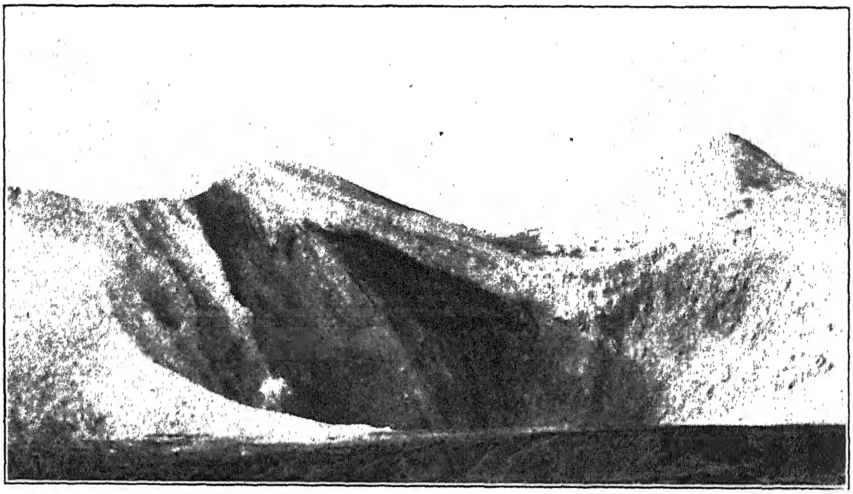
So much interest was displayed by the public in Lassen Peak that the first development to be undertaken in the park by the Federal Government was the construction of a standard, high-gear, paved highway to the very foot of this mighty volcanic mountain. Two years ago a fine trail, only 2½ miles in length and with a maximum grade of 15 per cent., was completed from this highway up the steep sides of Lassen Peak to the very top. From the register established on Lassen comes the interesting information that last season 5,255 visitors actually climbed this mountain and placed

[1] Photographs by author unless otherwise noted.

their names in the little book at the top. Many others made the climb, but for one reason or another failed to register. With the new trail, however, it is now a comparatively easy hike, and every Sunday hundreds of men, women and children can be seen, ant-like, wending their way slowly to the top of this semi-active volcano, to view, first hand, the result of one of nature's most gigantic and spectacular mountain-building forces.

But Lassen Peak itself is but little more than a molehill on the side of a once mightier volcano—Brokeoff. The Mt. Mazama, but every one that has visited Crater Lake in Oregon knows of this one-time mountain, for Crater Lake is in the crater of what was once Mt. Mazama. Both Brokeoff and Mazama, once towering peaks, have lost their proud heads by collapse, faulting and erosion.

Nothing is stable, least of all mighty mountains. Nature builds up a grand edifice, then before it is even completed starts its destruction. Witness the Grand Canyon as an example of just one of nature's destructive forces, erosion.



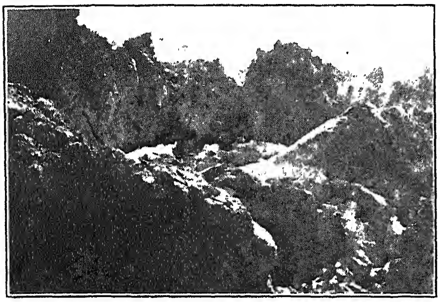
Photograph by B. F. Loomis

CRATER OF LASSEN PEAK ON NOVEMBER 10, 1914, AFTER THE FIRST SEASON OF ACTIVITY.

Lassen Peak Loop Highway winds its way up through the center and along the crumbling sides of this old Brokeoff crater. While it is not immediately apparent to the casual visitor that he is riding over what was once a seething cauldron of fire and "brimstone," nevertheless this is exactly the case, for the Brokeoff Volcano in its heyday was not only higher than Lassen Peak, but was responsible for the present height of the surrounding country for miles around.

The decline and fall of the Brokeoff monarch is much the same as the decadence of Mt. Mazama. No white man or Indian, so far as is known, ever saw

While Lassen Peak itself is not as spectacular in its present-day appearance as the public mind may believe—there is no yawning crater, no pit of boiling lava—yet clustered at the base of this mountain there are to be found six areas containing boiling pools of multi-colored acid waters; vents that hiss and roar deafeningly where live steam under tremendous pressure escapes from cracks in the ground; fascinating mud pots that build up small volcano-like cones or inspire awe with their deep-seated rumblings; small geyser-like fountains of boiling water and superheated steam. All this activity



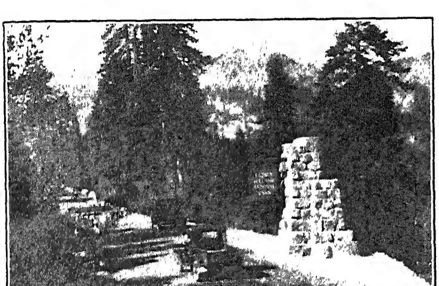
ROUGH, JAGGED LAVA

THE NEWEST IN CONTINENTAL UNITED STATES—FORCED UP IN THE CRATER OF LASSEN PEAK IN 1915 IN A VISCOUS, MOLASSES-LIKE CONDITION. A RANGER IS STANDING IN THE LOWER RIGHT-HAND CORNER OF THE PHOTOGRAPH.

and heat, mingled with the ever-present clouds of sulfurous steam, give a weirdness to these areas and create an atmosphere of the supernatural and unreal. It is impossible to set down in cold print the thoughts and emotions that come to the visitor as he stands in the midst of all this turmoil and activity.

Even the names that have been given to these solfataric areas are indicative of their character—Sulphur Works, the Devil's Kitchen, Bumpas Hell, Steamboat Springs, the Boiling Lake, Terminal Geyser. The activity is similar to that found in the mud pots and hot pools of Yellowstone National Park.

In the naming of Bumpas Hell the story goes that an old miner, known as Bumpa, in the early days had the extreme audacity to flout the warnings of



THE SOUTHWEST ENTRANCE

TO LASSEN VOLCANIC NATIONAL PARK IN THE SULPHUR WORKS AREA. LASSEN PEAK IS TO BE SEEN IN THE BACKGROUND DIRECTLY OVER THE NAME PLATE.

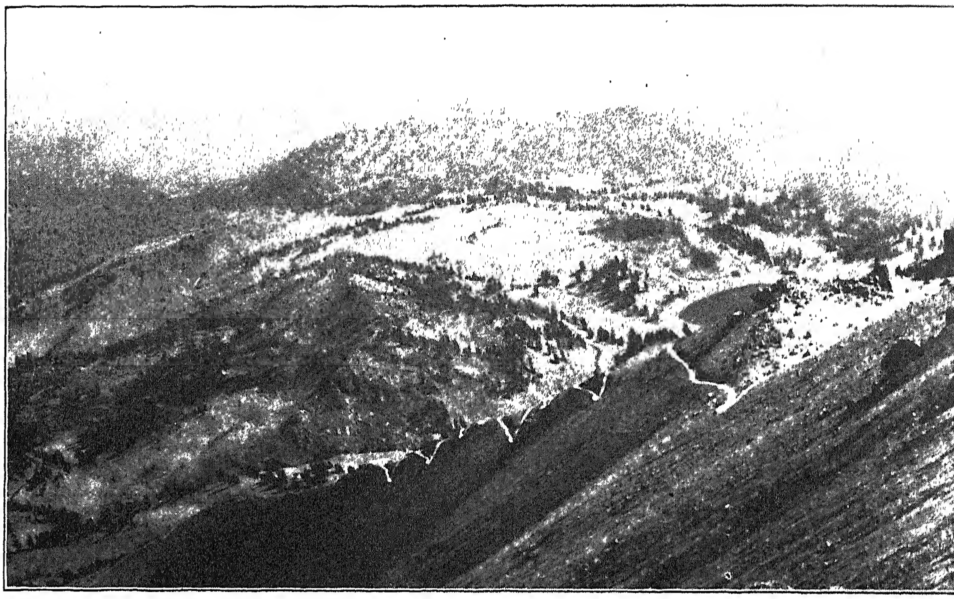
nature and start digging for minerals on the very edge of one of these "hot areas." One day, while poking around among the fumaroles and steamers, the ground suddenly gave way and his foot went into a small pool of hot mud. Now, old-timers were not particularly careful about their language under such circumstances, and Bumpa was no exception. The spontaneous expletive that issued from the mouth of Mr. Bumpa on this occasion was henceforth attached to his name to designate this particular area—"Bumpas Hell."

LOOKING BACK

FROM THE LASSEN PEAK TRAIL, THE WINDING LASSEN PEAK LOOP HIGHWAY AND BEAUTIFUL LAKE HELEN PROVIDE A SIGHT LONG TO BE REMEMBERED.

The Devil's Kitchen and Bumpas Hell are the two best known and largest of the park solfataras. The type of activity is similar, with only the elevation and setting different. Bumpas Hell is in a basin, about 10 acres in extent, on the rim of the old Brokeoff crater, and not over one mile from the southeast base of Lassen Peak. It is some 8,000 feet in elevation, and 1.3 miles by trail from the Lassen Peak Loop Highway.

The Devil's Kitchen is some 2,000 feet lower in the upper end of lovely Warner Valley. A dense growth of virgin fir,



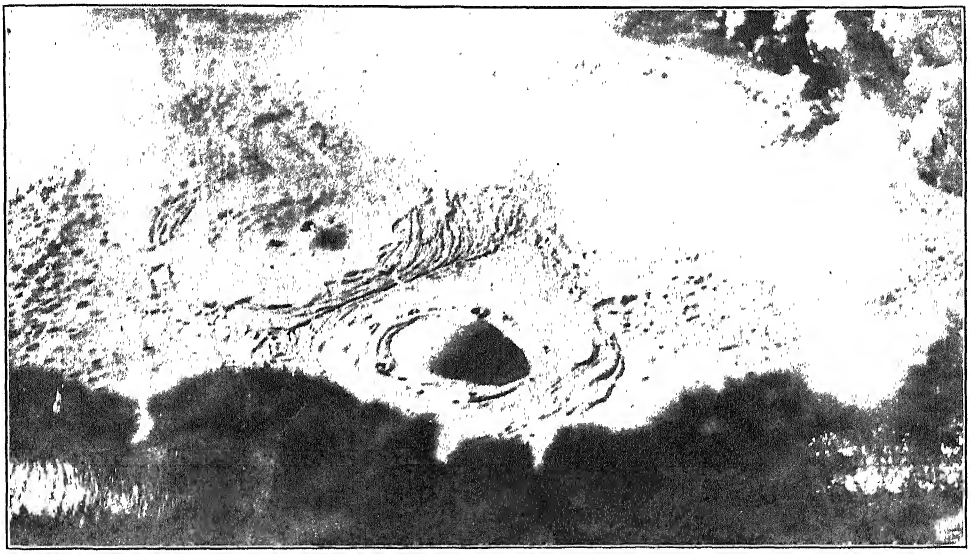
THE WINDING TRAIL UP THE STEEP SIDES OF LASSEN PEAK.

BUMPAS HELL IN MID-WINTER.

THE WARM GROUND KEEPS THE DEEP SNOWS MELTED AWAY. AT THIS POINT AN AVERAGE SNOW DEPTH OF OVER 10 FEET (LEVEL GROUND) EXISTS ALL WINTER.

pine and cedar trees surrounds the area, while through the center of all the hot activity there flows a beautiful mountain stream of clear, cold, sparkling water. It is here that the fisherman seeking the unusual can catch a gamey rainbow or eastern brook trout, and, without removing it from the hook or moving a step, toss it into a boiling pool and thus cook his dinner! A small resort on private land exists within two miles of the Devil's Kitchen and half a mile from the Boiling Lake. Deer graze in great numbers on the meadows near this resort, while horseback riding, swimming, fishing, hiking and other forms of recreation attract many visitors during the pleasant summer months.

One of these "hot areas" can be seen by automobile; in fact, the Lassen Peak Loop Highway runs within 100 yards of several active steam vents, fumaroles and boiling pools. This area, the Sulphur Works, is particularly interesting, because it is given by Professor Williams[3] as being the exact spot of the original vent in the old Brokeoff crater from which lava flowed and built up the overhanging cliffs of Brokeoff Mountain to their present height of 9,200 feet. This and other activity in the old crater suggest that fires still smoulder far beneath the surface and that some day a renewal of the old-time volcanism may occur.

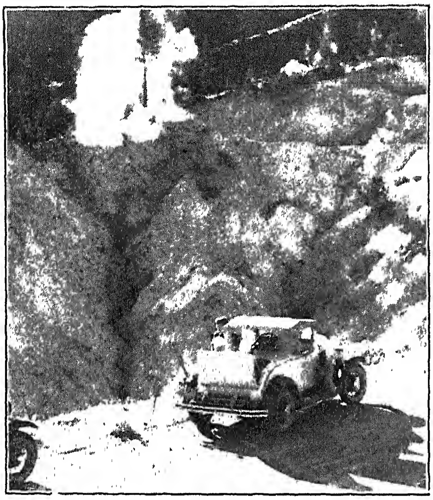


A GURGLING MUD POT IN BUMPAS HELL.
MAKING MUD PIES WAS NEVER AS FASCINATING AS WATCHING THESE LAZY BUBBLES RISE AND BURST.

Returning again to the somewhat fascinating question of possible future activity, the U. S. Geological Survey maintains an observation at Mineral. A resident volcanologist, R. H. Finch, resides here the year around and operates the observatory instruments.

Three seismographs are operated by the Survey at Mineral and in the park. They are arranged in a triangle around Lassen Peak, one to the north of Manzanita Lake, one to the south at Mineral, and the third, southeast of Lassen on Mt. Harkness. The seismograph at Manzanita Lake is located in a separate building in front of the museum, and visitors find it very interesting to stand and watch this delicate instrument at work. A ranger-naturalist is usually stationed at the museum who operates

[3] H. Williams, "Geology of the Lassen Volcanic National Park, California," *Bull. Dept. of Geol. Sci., Univ. of Calif.*, Vol. 21, No. 8, p. 244.



LASSEN PEAK LOOP HIGHWAY
WHICH CIRCLES AROUND AND PASSES RIGHT BY THE GROUP OF STEAM VENTS IN THE SULPHUR WORKS AREA, ONE OF WHICH IS SEEN HERE.

the instrument and is on hand to explain it and the other exhibits at this point.

During the first year of operation of the Mineral seismograph (1927) a total of 266 earthquakes were recorded on the smoked paper. Last summer (1933) over the 4th of July holidays no less than 34 distinct shocks were recorded on

TWO HUMAN FACES
FORMED ON THE 1915 LAVA IN THE CRATER OF LASSEN PEAK. CLOSE INSPECTION OF THE PHOTOGRAPH WILL REVEAL TWO MEN AT THE BASE OF THE UPPERMOST FACE.

this delicate instrument. While all the earthquakes felt here in recent years have been comparatively light, it nevertheless indicates that activity of some sort is going on in this region which may some day again startle the world.

But Mr. Finch has confidence that his instruments will tell him in advance of any future eruptions. He places his confidence chiefly on the small tilt-recording apparatus that is attached to the seismograph. It seems that the whole Lassen edifice is constantly rising and lowering; that is, tilting in one direction or another. This is due to the increase or decrease in pressure beneath the surface. The tilt-recording instruments tell the direction of this tilt and the amount.

Should the pressure beneath the surface become unusually great, it follows that this increase in pressure would tend to increase the tilt, which would in turn be recorded and noted on the seismograph, and predictions made accordingly on the possibility of an eruption. While Mr. Finch declines to state if, and when, Lassen will again erupt, nevertheless both he and the author see to it that they keep plenty of photographic plates on hand and ready for use!

Generally, Lassen Volcanic National Park, as far as its natural features are concerned, can be divided into two parts. The western half of the park is rugged, wild and spectacular in its jagged, alpine-like crags and peaks. Much of it is above timber line. In the silent, lonely winter months these crags rise above the glistening white snow fields in a striking similarity to the Swiss Alps.

While the western half is breathtaking and awe-inspiring, the eastern half, in direct contrast, is soothing in its effect. Innumerable gem-like lakes lie undiscovered in the extensive forests of pine, fir, hemlock and cedar. Flowing streams may be seen at the foot of rolling hills. An atmosphere of peace and calm prevails over the area. But exceptions exist here and there. One will

LAKE EMERALD,

NESTLED AT THE FOOT OF LASSEN PEAK. THOUSANDS OF HUNGRY RAINBOW TROUT LIVE IN THE LAKE AND VISITORS GREATLY ENJOY FEEDING THESE BEAUTIFUL FISH. IT IS A NATURAL AQUARIUM.

LASSEN PEAK AS IT LOOKS TO-DAY FROM ACROSS MANZANITA LAKE.

KINGS CREEK FALLS

suddenly come upon a jet-black, barren lava flow; a spire of lava will rise above the timbered slopes; a cinder-cone-topped extinct volcano will invite inspection.

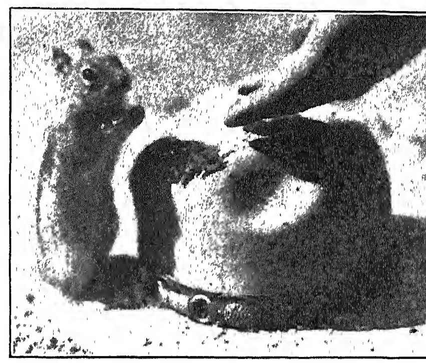
Such is the unexpected sight that presents itself to the visitor entering the northeast corner of the park. Surrounded by a forest of huge jeffrey pines, the trees abruptly stop and a wall of new, black lava rises from the sandy soil material. It is the lava flow from the Cinder Cone.

To write about the Cinder Cone, to try to describe it, is to depreciate its spiritual beauty. The Cinder Cone is a sight to be viewed in silent awe and appreciation. The cold facts are that the cone is 660 feet high, half a mile in diameter at its base, is in absolutely perfect symmetry and proportion, has a double crater in its peak, devoid of vegetation, dark-colored and made up entirely of small rock-like cinders. It is skirted on one side by the timbered slopes of Prospect Peak, and on the other side by a flat, undulating, fan-shaped field of jagged black quartz-basalt lava, the last flow of which occurred only 84 years ago.[4] Part of this flow is covered with a highly colored ash, known as the Chromatic Dunes; in all, a remarkable sight.

Snag Lake and Butte Lake, east of the Cinder Cone, were at one time one large lake. As recently as 300 years ago, lava flows from the base of the Cinder Cone flowed into this large lake, forming the two lakes named above. And now it is a strange sight to see this wall of black broken-up lava blocks extending out into the lakes, particularly as the opposite shore of both Butte and Snag Lakes are well timbered and diametrically opposite in appearance to the barren lava wall.

To add to the peculiarity of the area, the eruptions from Cinder Cone spread a sandy layer of volcanic ash, several feet thick, over fully 30 square miles of area. The majestic pines grow up through this sandy ash in a park-like stand, most beautiful to look upon. But woe betide the careless motorist who allows his car wheels to leave the two firm tracks and sink down in the loose, soft ash, for verily he will have much pushing and puffing to get back on solid ground.

As yet no paved roads have been constructed into Butte Lake; in fact, the park administration is debating the question, whether or not to keep this area undeveloped and unspoiled by crowds of visitors. There is a constant demand for more and better roads, but



NIP, BROTHER OF TUCK,

SPECIAL ASSISTANT TO THE RANGER AT MANZANITA LAKE CHECKING STATION AT HIS JOB OF WELCOMING VISITORS TO LASSEN PARK. NIP IS A SIERRA NEVADA GOLDEN MANTLED GROUND SQUIRREL WHO GOES BY THE IMPOSING NAME OF CALLOSPERMOPHILUS CHRYSODEIRUS CHRYSODEIRUS (MERRIAM).

there is also a demand for the wilderness area from that type of person who loves to get away from the crowd and enjoy nature alone or with his own little group. Butte Lake and the Cinder Cone, however, are at present only an hour and a half drive from the nearest highway, and the inconvenience of the dirt road is compensated by the beauty and interesting phenomena to be found there.

Geologically, Lassen Volcanic Na-

[4] Finch and Anderson, *Bull. Dept. of Geol. Sci., Univ. of Calif.*, Vol. 19, No. 10, 1930.

CRESCENT CRATER

DOZENS OF VOLCANIC MOUNTAINS AND CRATERS EXIST IN THE PARK. CRESCENT CRATER OCCURRED ON THE NORTH SLOPES OF LASSEN PEAK, SHOWN ON THE EXTREME RIGHT. AN IDEA OF THE DENSELY FORESTED TYPE OF COUNTRY CAN BE GAINED FROM THE TIMBERED FOREGROUND. THIS FOREST ORIGINALLY EXTENDED TO CRESCENT CRATER. THE 1915 ERUPTIONS, HOWEVER, DENUDED THE COUNTRY SHOWN IN THE PHOTOGRAPH AS BARREN AND FORMED WHAT IS NOW KNOWN AS THE DEVASTATED AREA.

tional Park is important for its recent volcanic activity. Geographically, this area marks the southern end of the Cascade Range. It is actually on the extreme southern tip of the volcanic platform of that range and less than 30 miles from the granitic Sierra Nevada. Biologically, the flora and fauna are not only plentiful, beautiful to the eye and abundant in recreational attributes, but also important to the botanist because here are found many hybrid species having characteristics of both the Sierra and Cascade plant life.

The area, up to the present, has been inaccessible except by trail and a few inferior roads. It was not until 1925 that the National Park Service first began active administration and development of the park. Since that time, work has been quietly but diligently carried on by building roads and trails, developing camping areas, constructing buildings, placing signs and otherwise opening up and developing the park for the numbers of visitors that will soon be coming to marvel at and enjoy the recreational, scenic, volcanic and geologic features found here in such abundance.

While Lassen Peak and the interesting volcanic exhibits are the first attractions to the public, it has been found that the fishing, hiking, camping and boating and the wonderful forests, innumerable lakes and streams, lovely high mountain meadows, birds, chipmunks, deer and other wild animals, the scenic drives and all the factors that make for enjoyable vacations in the mountains are what bring the visitors back to the park year after year. And now that accommodations at Manzanita Lake, Warner Valley and Juniper Lake are available, no longer will it be necessary for the visitor to camp out or hurry through in one day.

Lassen Volcanic National Park, truly a gem in a little known country, ranks with its older national park brothers as an area of which we can be justly proud.

WORLD POPULATION

By Dr. WARREN D. SMITH
PROFESSOR OF GEOLOGY AND GEOGRAPHY, UNIVERSITY OF OREGON

I

So much has been said and written of late years on this subject that one may seem presumptuous to add more words to the discussion, but the present writer feels that the point of view of the geographer has not been adequately presented, in this country at least. The public has been entertained, puzzled and even alarmed by such books as Ross's "Standing Room Only," East's "Mankind at the Crossroads," Pearl's "Biology of Population Growth" and Stoddard's "The Rising Tide of Color."

According to East:

> The facts of population growth and the facts of agricultural economics pointed severally to the definite conclusion that the world confronts the fulfilment of the Malthusian prediction here and now. Man stands today at the parting of the ways, with the choice of controlling his own destiny or of being tossed about until the end of time by the blind forces of the environment in which he finds himself.[1]

Mankind did not give this subject serious thought until the publication of Malthus's classic work on this theme. Since that date there have not been wanting writers who have liked to indulge in Cassandra-like prophecies of doom. We have had them in nearly every field of thought, and still the old world wags along and our raw materials have not become exhausted, our population continues to increase and civilization still endures. The same fault vitiates all these gloomy predictions. All these prophets of doom have lacked perspective.

In this paper the writer will attempt to criticize and synthesize some of the existing data on this subject of population, and bring to bear the point of view and information of the geographers and take issue with the biologists, journalists and novelists. At the outset it may be stated very definitely that there appears to be no reason for pessimism, nor for undue optimism. The writer's first thesis is that this subject is primarily a geographical one. This is readily proved by a mere enumeration of the factors controlling population, to which we shall return in subsequent paragraphs.

Certain books of comparatively recent date have been mentioned, but the reader's attention should be called to some other works if he is going to approach this subject with any degree of scientific accuracy. The "Proceedings of the World Population Conference" (Geneva, 1929) is a most important contribution. However, even this first great world conference on the subject had serious shortcomings, since in an assemblage of 123 delegates of economists, statisticians and biologists, only one lone geographer was present.

"Population Problems," by Warren S. Thompson, is the best general book on this subject in English with which the writer is acquainted. This book refers primarily to United States problems and especially to such subordinate topics as rural *vs.* urban and occupational aspects, with which we can not concern ourselves in this paper.

Another important contribution to the subject, especially of a statistical nature, is Kuczinski's analysis under the title, "The Balance of Births and Deaths." Dr. L. S. Cressman, of the department of sociology, University of Oregon, has made a brief abstract of this paper for the present purpose, since it lies in his field of statistics. Quoting his statement:

> The changing age composition of the different populations of the world has a marked effect

[1] East, "Mankind at the Crossroads," Preface, p. 8.

on the birth and death rates. Improvements in health and sanitation have reduced the deaths of infants and children so that now we have a larger proportion of the population in the middle age groups, or the age classes marked by low mortality. In addition to this, the birth rate has been reduced by the use of contraceptive devices. The birth rate per 1,000 population would seem to be likely to increase for a time in view of the changing age composition, but on the other hand, birth limitation reduces the rate of births. The difference between the decreased death rate and the birth rate will not be so great in view of contraceptive techniques. But with the reduced proportion of children in the population eventually a time will be reached when there will be an excess of aged people, so that the death rate will increase for a time. Time will correct this, and probably the result will be, as in France, a stationary population. This does not apply, however, to great masses of the world's population at the present time.

The present writer has no intention of questioning Kuczinski's conclusions. He is not here attempting to settle the problem of the world's actual population, but the larger and perhaps more important aspect, namely, the world's possible population under the most favorable conditions. Of course, at the present time, during the world's most serious depression in modern times, we see population growth severely retarded in many countries, especially in those like our own where industrialism is so important. It may be that such checks as these and those produced by floods, famines, war and disease will always remove the danger of over-population.[2]

In the writer's own treatment of this subject, he will draw heavily upon four sources of information and interpretation: First of all, there is the well-known professor of geography at the University of Berlin, Albrecht Penck, who has taken the lead in this subject abroad. The writer had the great privilege of being a member of Professor Penck's seminar on this subject at the University of California a few years ago. Second, Professor Griffith Taylor, formerly of Sydney, Australia, now of the University of Chicago, whose book "Race and Environment" is one of the standard works in geography. And third, the publication resulting from the Geneva Conference. Finally, the writer will draw upon his own observations in many parts of the world extending over a period of twenty-five years of travel. Many loose statements of certain publicists to-day can be properly checked only by observations on the ground.

Let me hasten to state that the writer does not regard himself as infallible in this field, and many of his statements are tentative. The vastness and complexity of the problem should cause any one, particularly a scientist, to be cautious and reserved.

II

A rapid survey of the factors controlling population will reveal both the intricacy of the problem and at the same time the compelling need for some humility in attempts properly to appraise it, to say nothing of trying to solve it.

The primary factors as usually given are: natality, mortality and migration. It is obvious that the rates of birth and death and their ratio and the shifting of peoples from one region to another are the primary factors in population, and no one would question the part played by the secondary factors, climate, food, shelter and power resources in influencing the first named, though each of us might weight these effects differently.

The writer does not propose to spend much time on these points, as they have been discussed by all those who have pretended to any serious study of the subject. He will, however, call attention to some other factors and considera-

[2] A very recent and exceedingly important report of the Second General Assembly of the International Union for the Scientific Investigation of Population Problems, held at the Royal Society of Arts, London, from June 15 to 18, 1931, has been referred to in *Nature*. The present writer regrets he has not had access to this report.

tions that have not always received adequate attention.

The effects of light and barometric pressure as a part of climate should be touched upon for a moment. We have as yet too little data on which to base much that is conclusive in this field. Some years ago the late Dr. Woodruff of the United States Army made quite a study, though inconclusive, with reference to the effects of tropical light, particularly on white men, and came to the conclusion that light in the tropics was a serious factor in the population of tropical regions by men who were not sufficiently supplied with pigment in the skin. Probably both excessive light and low barometer affect not only man's well-being in the tropics, but also his fecundity. On this last point the writer knows of no data. He merely calls attention to an interesting subject for research.

The biggest factors to-day, probably in this whole question, are science and invention in modifying our climates or offsetting the effects of climate and food shortage. In the beginning Pearl's studies on population growth were referred to. Pearl studied the rate of growth of Drosophila, a fruit-fly, in cultures of a definite amount of food and found that their multiplication followed a definite curve, the so-called logistic curve (Fig. 1) and drew the analogy between the fruit-flies' growth and that of human beings. This would be very well if human beings were confined in a large bottle and had no access to any other food than what was supplied to them in this bottle. And human beings in certain localities have had a growth curve which was remarkably like this curve, but in several instances this normal growth curve has been interrupted and the growth increased due to some change in that locality whereby more people could be supported, and the curve has again ascended. The food supply was not fixed, that is to say, this is a variable, and furthermore food supply depends upon other variables.

At this point attention should be directed to this danger of using formulae and trying to express such matters by means of mathematical terms. This is

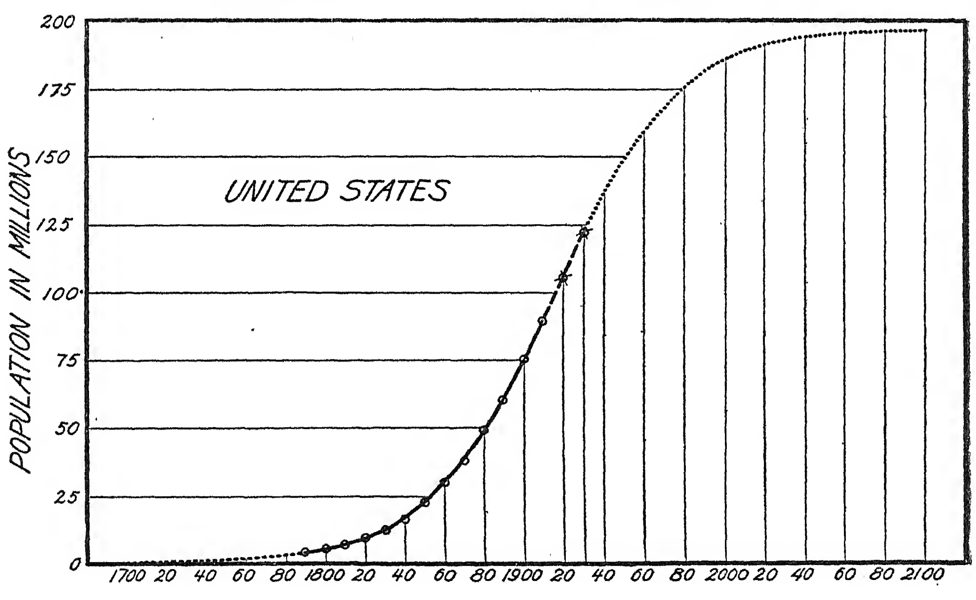


Fig. 1

all right if one knows all the factors and just how to weight each one. It is quite proper for the biologist and statistician to attempt to do this thing, but he must be very careful not to jump to conclusions on the basis of such expression, and several European scientists have taken Pearl to task for this very thing.

On this subject Wilson and Puffer say:

> If by the statement that the logistic, whether augmented or not, is the law of population growth, one means only that the formula is well suited to fitting the census enumerations for the period of a century or so when such enumerations have actually been made, we can take no exception to it, for we have shown that those enumerations can be fitted even more closely than they have been fitted by others. But if the statement is to be considered as signifying that the formula affords a rational law to such an extent as to permit the extrapolation of the curve for forecasting purposes and the interpretation of the constants as constants of nature, we are forced to take serious exception to it, because we find that there are too many instances in which the curve becomes infinite in finite time or has a negative lower asymptote or both and because the constants are too often so poorly determined as to be practically undetermined; in all these cases we must at least withhold judgment until the populations have developed so far toward saturation that the fitting of the curve will give reasonably well determined indications of the saturation values.[3]

Five very important factors, for which science is in part responsible, have changed the complexion of this entire problem of population, and to these we would direct your attention now. They are: (1) Irrigation and improved agriculture. (2) The preservation of food by canning, refrigeration and desiccation. (3) Transportation of food, as well as human beings, from one place to another. (4) Conquest of disease and improvement of health in man. (5) Conquest of disease in crops and animals.

[3] *Proceedings of the American Academy of Arts and Sciences,* Vol. 68, No. 9, August, 1933—Edwin B. Wilson and Ruth R. Puffer, "Least Squares and Laws of Population Growth," p. 340.

The first, irrigation, is of course an ancient practise, but modern science has enormously increased the effectiveness of it. The improvements in agricultural practise, particularly in the direction of mass-production, has to-day given us more food actually than we can consume.

Man is growing wheat much faster than he is eating it, so that much of the present distress in agriculture is due to an evil long familiar to manufacturing—simple overproduction. This was the thesis of an address by G. V. Jacks, of the staff of the Rothamsted Experimental Station, delivered before the British Association. During the last twenty years the world's wheat area has been increased by over 20 per cent., and production by over 25 per cent.; the increase in population over the same period has probably not been more than 14 per cent. The causes of this overproduction have been very complicated, and are hard to analyze; but economic, scientific and political factors have all played their parts.

Similarly, through our ability to can, freeze and dry food we have eliminated famines in those regions where these practises are carried on. One scientist, Free, has said that in his opinion the canning of food is perhaps the greatest scientific discovery man has made.

Think of what it will mean to the undernourished millions of Asia when we transport to them millions of gallons of fresh frozen milk, as we are beginning to do.

In the conquest of disease and in the improvement of public health, we have another potent factor, the full import of which we are just beginning to learn. The reader is invited to read the romance of the American doctor and sanitary expert in the one restricted field of the Philippine Islands alone. The change wrought in that archipelago reads almost like a tale out of the Arabian Nights. The famines of China and India need not occur at all to-day

and will, in time, become a matter entirely of the long-forgotten past. There is enough knowledge and skill and food available in those lands to banish these terrible scourges if men there could be made to change their age-old practises.

In our survey of the world to which we shall next turn we shall have always to consider density of population. Let us analyze this. First, we shall use a formula derived by Penck, not necessarily to prove something, but in order to clarify the discussion. Perhaps we may have to change this formula somewhat or even get a new one entirely. As it is, perhaps, the best available at present, we shall use it. Productive power (K) of a region is dependent upon *climate* and *soil*. Intensity of production depends largely upon character of people, that is *race*. Need for production depends upon a number of things, density principally and geographical situation.

$$\text{Density of Population} = \frac{\text{Natural Productive Power} \times \text{intensity of Production of Region}}{\text{Need for production (food)}}$$

or using symbols:

$$d = \frac{Ki}{n}$$

Wherein d equals density of Population
K equals Productive power
i equals intensity of production
n equals need

III

This made clear, we shall now carry out a rapid survey of the world's natural regions, using the salient facts of climate, soil, race and present population, and attempt to arrive at an estimate of possible future population saturation following Penck.[4] And finally, when this has been done, we shall devote some little time to a consideration of the, to us, all-important sub-topic, the expansion of the white race, to which Griffith Taylor has devoted so much research. To us on the Pacific Coast there can be no other topic quite so relevant to our situation.

In our regional survey the writer will make use of Köppen's classification of climate, since climate is perhaps the most important single geographic factor affecting population. Again, we are indebted to a German geographer[5] for guidance in our attack upon this problem.

It should be understood at the outset that these estimates can be *tentative* only. Space does not permit the writer to give all the details of the discussion necessary to arrive at the following figures. Briefly the method entailed a close scrutiny of all the factors affecting population growth in each climatic region and a comparison with regions wherein conditions were as nearly as possible ideal and a consideration of every militating factor. Of course biologists and geographers would emphasize these differently, and perhaps no two men in the same field would weight these alike. It may be said, however, that in Professor Penck's seminar where this survey was made the group of about a dozen students, chiefly professors or advanced research workers, collectively had personal first-hand knowledge of practically every climatic region of the globe.

(1) Beginning with the *Tropical Rain Forest* (Af and Am Köppen) you will note on the chart the limits of this region. This comprises about one tenth of the land area of the world, or 5,400,000 square miles. During no month herein does the mean temperature fall below 64° (18° C.) while the precipita-

[4] Albrecht Penck, "Das Hauptproblem der Physischen Anthropogeographie," *Zeitschrift für Geopolitik,* Heft 5, Jahrgang 2, 1925.

[5] W. Köppen, "Grundriss der Klimakunde."

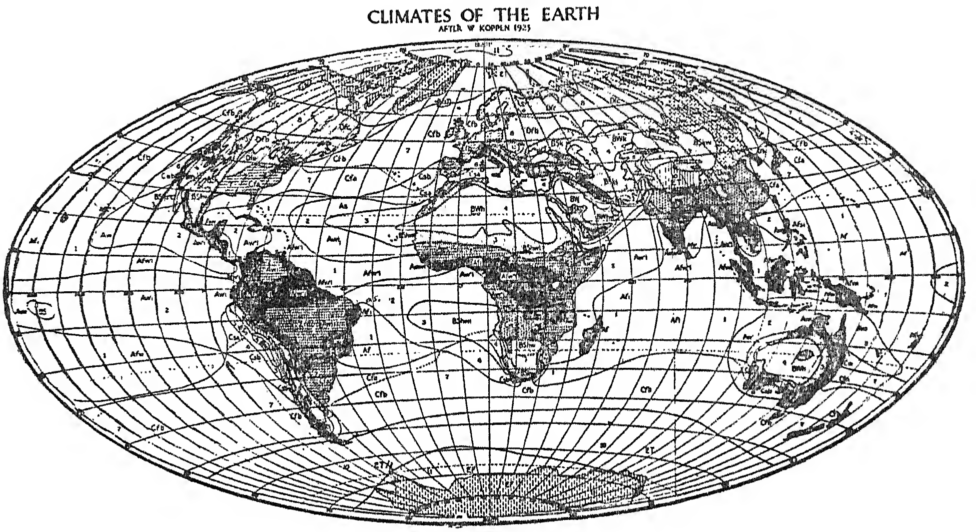


Fig. 2

tion in the driest month is in excess of 2½ inches. Over much of this area deep, rich volcanic soils prevail, and the vegetation covering is exceedingly luxuriant (Fig. 2).

The island of Java gives us the clue to population possibilities in this part of the world. Although the island is by no means a plains country, there being many volcanic mountains and rugged terrain, the population here is about 500 per square mile. On the basis of this a possible total population has been estimated by Penck at 2,800,000,000. Personally, the writer subscribes to somewhat less and places his figures at two billion. Even so, this is almost equal to the present total world population, which is estimated at about 2,024,286,000. The reason for cutting off some 800,000,000 from Penck's estimate is that it is extremely doubtful whether the intense land cultivation in use in Java could ever be duplicated in the remainder of the equatorial belt. Rich soil, an energetic, highly intelligent kind of people driven by the Dutch colonial system have all combined here to produce a remarkable result.

As a food reservoir this region will, in the opinion of the writer, in time, if not now, be more important than mesothermal (temperate) regions.

(2) *Tropical Savanna region* (*aw Köppen*)*:* This climatic region has a distinct dry season with .24″ in the driest month and no month with a mean temperature below 64° (18° C.). The Madras Residency in India is a typical example. There are approximately 6,300,000 square miles of available land in the tropical savannas. In the Madras Residency there are about 225 persons per square mile.

Two other great areas can be further populated, the Deccan of India and the Matto Grosso in Brazil.

On the basis of these figures it has been estimated that 1,413,000,000 total population is possible in the tropical grasslands of the world. Here again, we would trim these figures down to one billion, since we do not believe that the same density of population can be maintained in these areas outside of India. The advantage in India lies partly in the English over-lordship and partly in the people themselves.

(3) *Dry Climate Regions* (*B—Climates of Köppen*) : Here we must con-

sider two sub-regions, the deserts (B–W Köppen) and the Steppes (B–S Köppen).

In the deserts, of which central Asia and the Sahara are typical examples, the range of temperature is from 33°–117° F. (1°–47° C.), while precipitation varies between 2″ and 5″ per annum.

The population is about .25 per square mile, and the total areas of all such regions will come to something like 11,000,000 square miles. Penck estimates 18,000,000 as the possible number of people who could be supported. Of course this presupposes much more efficient living than one finds in most of these regions to-day. But this is not at all unreasonable to expect with the advance of modern knowledge into such areas.

We have been reading a most illuminating book recently, "The Mysterious Sahara," by Prorok, which reveals the great wealth of cities that once existed in that forbidding territory, and it appears scarcely possible that change of climate is solely responsible for the depopulation there. It is highly probable that wars, disease and racial decay have been quite as potent factors in this remarkable eclipsing of those ancient civilizations. On the other hand, if we follow Huntington, we must lay the chief blame upon change of climate. We can not, in the light of present knowledge, be too positive in our conclusions.

In the steppes, of which the lands contiguous to the River Don of southern Russia are an example, the temperature range is between 82° and 97° F. (28°–36° C.) with a precipitation of 14.5″ per annum and 2″ the greatest amount in one month.

At present the population runs about twelve per square mile, and there are 13,200,000 square miles of such lands. The total population estimated for the steppe land is 106,000,000. What the ultimate possibilities of these regions can be largely depends upon the present experiments on the part of the Russians.

(4) *Mesothermal Climates (C—Climates of Köppen):* Here again we have two subdivisions to consider, a moist temperate and a dry temperate.

The mesothermal climatic regions are for the white man, and for all but the black race, and for world civilization the most important.

The moist temperate climatic province can be further subdivided into a region wherein the winters are moist like China and western Europe, and a second region like Bengal where the winters are dry. We might even consider eastern Asia as distinct from western Europe and the United States because of its distinct Monsoon climate which has its own climatic peculiarities.

In the first-named region the precipitation varies from 20″–57″ and the temperature from 27°–66° F. (3°–18° C.).

At present the population density is placed at 250 per square mile, and the total area is 37,000,000 square miles.

If China and Russia and parts of South America become industrialized to a degree approaching that of Western Europe and certain waste lands in China be reclaimed, this vast area ought to support a prodigious population. This of course will depend to some extent upon certain economic adjustments, perhaps like those now on trial in Russia.

Penck concludes that this first subdivision can support 930,000,000 people, or one half the total for the globe at present.

Think for a moment what this means for the people of Europe and America. It is fairly plain that we probably can not maintain our material standard of living and still adhere to a ruthless competitive system. As much as we may wish to, we can not resist inevitable changes in our social and economic structures.

It behooves us to say just a word concerning standards of living. The tariff boosters particularly lay great stress upon the "American standard of living," meaning by this plenty of bath-

tubs (and one or more baths a day, which of course is not necessary outside the tropics) motor cars, white flour bread, etc. Nothing is said about the low level of this sort of emphasis upon creature comforts. Perhaps it does not enter the head of the Senator from Utah that perhaps the lowly Japanese with his flower gardens and temples and philosophy of jiujitsu may actually have a higher standard of living than an American movie star.

In the Bengal type of region, warm and with dry winters, the range of temperature is from 32° to 116°—hot rainy summers, with a precipitation of 25″. Here the population density is 228 per square mile and 8,000,000 square miles all told.

Assuming that this density can not be maintained for the entire area, but only one half of it, we would have about 900,000,000. Penck's estimated population for this region is 1,243,000,000.

For the dry temperate, California, the Mediterranean and central Chile, we have the following figures: Temperature, 32° to 64° for the mean range; precipitation in winter 17.6″; population density, 125 to 250 per square mile, 225,000,000 total population estimated.

Much of this region, like Italy, has 250 per square mile, and the Los Angeles area a great deal more, and if we calculate upon a basis of 1,500,000 square miles total area, and 150 per square mile, we can easily reach the estimated total given above. The writer would be inclined to divide this by at least two, because of mountainous and other types of relatively waste land.

(5) *Microthermal Climates (D—Climates of Köppen):* These are the cool temperate climates, and we may subdivide them into two—the winter dry type exemplified by northeast Siberia and the winter moist type exemplified by Canada and western Siberia.

In the first subdivision we have a range of temperature from 58° to –90° F. (15° to 50° C.), the extremely low temperature being recorded at Werchojansk, Siberia. The precipitation averages about 5″.

Penck believes that this region could support 75 per square mile, but hardly under present conditions. This would give close to 200,000,000 population. A great deal of drainage would have to be resorted to in order to make these lands suitable for cultivation, but this is not an insurmountable obstacle.

In the second subdivision the range of temperature is not so great, nor do we have such extremely low temperature and the precipitation is about 21″.

With an estimated area of 15,000,000 square miles it is thought that 735,000,000 people might be supported, but of course this is a long time in the future. Since the writer's recent trip through Alaska and the Yukon territory, he is inclined to reduce Penck's estimates considerably and divide his figures by two or even three, let us say then 300,000,000 only.

(6) *Tundra Climates (E—Climates of Köppen):* In regions having tundra climates the temperature in the warmest month varies from 32° to 50° F. There is a slight summer precipitation.

Such regions as the Arctic, of course, will never support many people, and all told they will never amount in the aggregate to more than a half million, in all probability. In spite of Stefansson's optimism the "Friendly Arctic" will doubtless never prove to be a reality. Even according to his own experiences it can hardly be so described, since it is reported that eleven men died on his last expedition into that region.

The real value of the Polar regions is not as habitats for man, but as producers of food. Shipping of reindeer meat to the United States and Europe to-day indicates what this may amount to.

(7) *Climates of Perpetual Frost (F—Climates of Köppen):* Examples of these are Greenland, Antarctica and the

Himalayas. The population for these is practically nil.

If we sum up all these regions, we have a grand total of 5,666,000,000 as against 2,024,286,000[6] present world estimated population. Penck's total estimated possible world population is 7,689,000,000.

It is of course quite improbable that the world population will ever reach the stupendous total estimated in the above paragraphs. Wars, diseases, the natural curbing of the birth rate with the shifting of civilization from an agricultural to an industrial basis, to say nothing of the operation of birth control and birth selection, which will probably be practised much more in the future than in the past, will tend to keep the population more or less static in many parts of the world, as it is to-day apparently in France. An attempt has been made here to show the number of people that the earth might support, to bring out how complex the whole subject is, and to emphasize that a true appraisal can not be arrived at by any one group of specialists alone.

IV

One of the related problems which is suggested by this study is for us of extreme importance, and that is, where will the white races go? On this subject Professor Griffith Taylor has given us some very interesting discussions in his book on "Race and Environment."

Now, the white race is limited by climatic factors quite definitely, or has been in the past, and also by certain economic factors. Taylor asserts, and we believe with good reason, that these "controls" are (1) Altitude, (2) Temperature, (3) Precipitation and (4) Coal. In the larger world picture coal

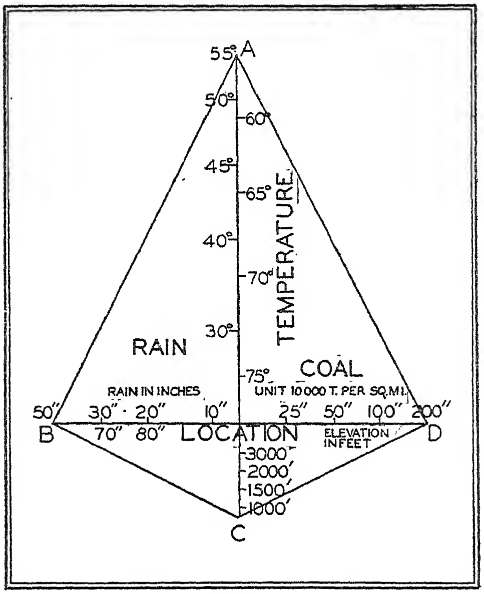


Fig. 3

far outweighs in importance wood and water as a source of power.

He has worked out on the basis of these a very expressive "econograph" which, in the case of the ideal conditions which he sets up, resembles the frame of our old-time American kite, as indicated in the diagram (Fig. 3).

Here we have, according to his scheme:

Rainfall (or snow)	50″
Temperature	55°
Elevation	sea-level
Coal	200×10^4 tons per sq. mile

From these he computes an ideal econograph with 1,000 units as the maximum and thus surveys the world to see how each political subdivision fulfils these conditions. It is interesting that the British Isles and North China come nearest, with 770 units each, to reaching the ideal. The northeastern United States comes second with 755 units, and the interior plains of North America third with 675.

The writer would modify Taylor's econograph in several details. First, he

[6] This latest estimate of the number of human beings in the world that has come to the writer's notice is made by Professor A. M. Carr-Saunders, of Liverpool University, who states that the number is increasing about twenty million a year.

would extend the altitude limits to 1,000 feet above sea-level, since many of the world's large agglomerations of people are found well above sea-level, but relatively few above 1,000 feet.

While 55° may be the optimum temperature, large populations of white people are found living at a somewhat higher average temperature, though not much above this. This figure might easily be raised to 60° without much loss to either physical or mental efficiency.

50″ of rainfall requirement is also unnecessarily high, and I would consider 40″ as sufficient, since a foot of controlled water is worth as much as three feet of flood water, and the use of water in the future will be more and more controlled and conserved.

Likewise with advances in technology, electricity from water power will more and more supplant the use of coal, so I would allow for that in my estimates of power resources.

These modifications somewhat alter the picture of white race expansion. Under Taylor's scheme the white race with its particular industrial civilization is pretty definitely limited. Into certain desirable regions like eastern Asia it can not go because these are preempted by peoples we can not compete with on any terms. Into other regions like the Tropics we can not go, according to Taylor and Huntington, because of climate.

With Taylor's conclusions Penck and the writer do not agree altogether. Under pressure of population and need for economic exploitation the white race will be forced to expand beyond its present habitat, and indeed at the present is doing so. In fact, it has done it in the past. The so-called Aryan branch of the white race moved very slowly in the past down into India and occupied a sub-tropical region, even though in doing so it became dark-pigmented.

In South America they have moved into another sub-tropical region, Brazil, and are living there very successfully. In two other regions they are now advancing slowly into the Tropics, from southeastern Australia into Queensland and in Africa from South Africa into east Central Africa, very slowly it is true, but doing it. The important thing is that it is being done *slowly*. We have heard much of the effect of the tropics upon the white man. On this point the late Colonel Woodruff, U. S. A., was very emphatic in saying that white men could not live permanently in the Tropics. In this the writer is in very emphatic disagreement with his findings. Of course if one goes abruptly, suddenly from a temperate region into the Tropics the effects are bad, but if the race takes it slowly, many generations, it can be done, is being done and has been done.

One very interesting and extremely important point in this connection made by Penck is that these great movements of whites into Subtropical and Tropical regions are by way of *east coasts* at the present time. Rainfall and tempering sea breezes are here the chief factors. An important consideration here is the fact of misecegenation attendant upon these migrations.

Two other points must come up for consideration in this expansion of the white race, namely, fecundity and birth selection. It has been shown that the darker races breed faster, but the whites bring up more children. Furthermore, in the intense competition of the present and the future, birth selection will play a greater and more important rôle than in the past.

On this point East says:

> If the human race really desires a continued progress, a fair chance, a longer and happier life for every individual, the birthrate must come down faster and faster; and it must come down throughout the whole population and not merely within one section which furnishes those of greatest social worth. To accomplish this, parentage must not be haphazard.

Intelligent persons not wholly swayed by irrational tradition and emotional prejudice will be disposed to accept the idea of rational parentage as wholesome and proper. At the same time one should be under no illusion as to what is likely to be the immediate fate of a social scheme which requires an appreciative forethought by whole peoples, and not merely acceptance by the intelligentsia. No matter how much suffering could be prevented, no matter how much greater a civilization could be built by its application, its general adoption will probably await the compelling force of economic necessity. What else could be expected? Half the people in the world lack sufficient brains to cope with the intricate system of social life the industrial age has brought about. Half the remainder are without the proper training; they lack the power of knowledge. The remaining quarter, who might worthily direct the great majority, sit complacently as long as they are permitted to take an extra toll of the good things of life, and watch the direct control of the destinies of nations remain in the hands of those whose chief claim to the honor is the ability to emit those hollow words which fill *The Congressional Record* and the parliamentary debates. Knowledge is not wisdom. Knowledge to prevent the decay of our social fabric is not wanting; but it is a serious question whether there is the required amount of that type of ability which will make a sustained effort to apply it.[7]

The darker races are beginning to practise birth control, but it is doubtful if they have as yet learned much about the more important thing of birth selection. Japan is a notable exception to this statement.

On this subject we would like to make the observation that of the two, birth control and birth selection, the latter is much more to be desired, and it is imperative for all nations to take some steps in this direction. These matters can not longer be decided on religious or sentimental grounds. It is much safer for us here to follow the lead of the social scientists.

Let us turn to Osborn on this subject:

With such principles in mind, and with the picture before me, of the world suffering acutely from dysgenic reproduction, from the multiplication of the incompetent, and from the alarming increase in the power of the criminal class, I can not refrain from expressing my deep conviction that, of all remedial and restorative agencies, the well-understood and well-applied principles of birth selection advocated by Galton, with birth control as a subsidiary principle, stand in the very front rank of progressive civilization.[8]

In all the shiftings of population, migrations and invasions an inevitable change in color tone of man will take place, in fact, has been going on and will increase. A certain unavoidable amount of miscegenation will and must go on, which will result in a tendency to greater pigmentation. If one looks at it fearlessly and free from prejudice, he will come to realize that brunette whites will probably dominate the earth, unless of course there should be some sudden, powerful eruption of the blacks, in which case the future earth population will be darker still.

Finally, the resurgence of the Nordics, so stanchly championed by Hitler in Germany and by Madison Grant in our own country, can not in the long run be permanent, as biological, and not political factors, fecundity and ability to underlive other peoples will in the last analysis decide the issue. Perhaps "the meek will inherit the earth" after all.

Conclusions

(1) This problem of population is one for geographers, primarily.

(2) The population saturation point is now placed too low.

(3) The logistic curve for Drosophila and other organisms does not necessarily fit human beings.

(4) Birth control and birth selection are imperative if a high plane of civilization is to be maintained.

(5) The Tropics is now the great goal of the whites.

(6) Brunette whites will probably dominate the earth in time.

[7] Edward M. East, "Mankind at the Crossroads," p. 350, ch. 12.

[8] H. F. Osborn, *Science*, August 26, 1932, "Birth Selection versus Birth Control."

TECHNOLOGICAL UNEMPLOYMENT

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UNEMPLOYMENT is the most difficult social question of our time. Naturally, the remedy for the situation will depend upon our diagnosis of the cause. It is frequently alleged at the present time that one important contributory cause is the displacement of man by machinery — technological unemployment. Since the accusation calls in question the social benefits of the great technological advances due to scientific research, it has aroused a certain amount of alarm in the scientific world.

Quite recently certain distinguished physicists have rushed to the defense of science in articles purporting to prove that the blame for unemployment can not be laid at the door of technology. Good statements of their views are given in papers by Dr. Karl T. Compton, Dr. Robert A. Millikan and Dr. W. D. Coolidge in the SCIENTIFIC MONTHLY for April, 1934. In general, their arguments may be reduced to four. I propose briefly to state each of these in turn and then to comment upon them at some length. I think I can show that some of these arguments, when carefully examined, are not altogether convincing.

The first argument is that science is a great benefactor of mankind, to which we owe our advances in civilization, our increased control over nature and our modern high standard of living. To blame science for our troubles is therefore to accuse the thing which is helping us most.

No one will deny that science has conferred enormous benefits upon mankind, but recognition of this fact leaves the problem of technological unemployment entirely untouched. The point is that this progress has been achieved at the cost of great and undeserved hardship to many individuals. This has been to a certain extent the case ever since the industrial revolution began, but the problem has become accentuated with the great acceleration of technical progress in the last decade. It is a great mistake, however, to think that it is a phenomenon which became apparent only during the depression. Sumner H. Schlichter, in an article in *The New Republic,* February 8, 1928, entitled the "Price of Industrial Progress," said: "We are obtaining more and better industrial equipment only at the price of heavy investment in unemployment and human misery. We are not getting a bargain. We are purchasing progress at a high price, and the cost falls largely upon those least able to bear it." Is it not fair to ask that society should come to the rescue of these unfortunates? We may scrap obsolescent machinery without scruple if we see any economy to be gained thereby, but to cast aside human beings who have been productive workers is another matter.

There are three parties interested in every technological change: (1) the employer, (2) the consuming public, (3) the workers whose jobs will be affected. As things stand, the question of whether the change shall be made or not is decided exclusively by the employer, who need consider only whether it will result in profits for himself and those he represents. The consumer may perhaps benefit if the business man passes on to him any of the resultant saving, but for the displaced workers it is a calamity equivalent to bankruptcy. In the United States until recently, their fate was regarded as being nobody's business but their own; however, the sheer magnitude of the problem has now compelled this

country to join other leading industrial nations in assuming responsibility for the unemployed.

The second and, if proven, the strongest argument brought against the idea of technological unemployment may be succinctly stated as follows: Science creates new jobs by creating new industries. More new jobs are created than old ones destroyed. For example, the automobile industry employs many more persons than the old carriage and harness industry which it largely supplanted.

This argument to a large degree questions the existence of unemployment caused by technological advance. At all events it regards it as temporary and unusual and as tending to be corrected by the very progress of technology itself.

If certain necessary qualifications are made, we may admit that this contention had a large element of truth down until the last decade. No one will deny, for instance, that the automobile industry, with its many subsidiaries, has given employment to millions of men, nor can it be gainsaid that this industry, and many others less gigantic, are founded on modern science and invention. However, we can not properly infer from statistics showing, for example, that the number of persons employed in the automobile industry is far greater than the number ever employed in the carriage and harness industry, that no problem of technological unemployment was created when one industry largely displaced the other. Statistics deal with men in the mass; they tell us nothing as to the fate of individuals. Yet common sense will tell us that persons for whom a new invention provides work are often not the same persons that it displaces from other jobs. Many people have installed electric refrigerators; the manufacture, sale and servicing of these has created jobs for electricians and others, but these are not the same people as were concerned in the manufacture, storage and delivery of ice.

Some economists meet this problem by the statement that ultimately, "in the long run," the displaced workers will be taken on at other jobs. What we must not overlook is that the worker is vitally interested in the short run. Any prolonged period of unemployment will soon wipe out whatever savings he may have made from his slender earnings as a provision against sickness or old age. Furthermore, in the case of a skilled worker he loses the considerable investment represented by the acquisition of his particular skill. It affords cold comfort to the victim of technological advance to be told that in due time, if in the meantime he can retrain himself for a new kind of work, he may again be employed or that his son will find a job if he can not. Labor is not a fluid form of energy like electricity, which can just as easily do one form of work as another. The idea that the laborer can "find another job" often assumes a knowledge of industrial conditions, a mobility and an adaptability on his part which he does not possess.

The above considerations show that technological unemployment is not new. However, it exists in a much more acute form to-day than ever before. It is not safe to ascribe this condition merely to the depression; indeed, the converse may be true, that the depression is in some measure due to it. The fact is that technological unemployment was becoming marked while we were still (officially) enjoying unprecedented prosperity. Figures released by the Bureau of Labor Statistics in 1928 showed that during the previous five years factory employment in the United States dropped 15 per cent., although population grew by 5 per cent. over the same period. An article published in the *Literary Digest*, March 24, 1928, entitled "Machines Driving Men out of Work," was accompanied by two charts, one showing that industry was

producing more with fewer hands, the other that farm employment was less with more output. Evans Clark, writing in the *New York Times,* pointed out that the crisis in employment was unprecedented in character, because it accompanied prosperity, not hard times.

This tendency toward increasing output with decreasing employment has continued in many lines during the years of depression. For example, in the electric lamp industry, according to the *Monthly Labor Review* of June, 1933, the production of lamps rose from 362 millions in 1920 to 503 millions in 1931, while the number of man-hours worked decreased from over 36 millions in 1920 to less than $11\frac{1}{2}$ millions in 1931. Expressed in index numbers, this means that the index of production rose from 100 to 139, while the employment index declined from 100 to 31.7. In the period 1916–1919 the average production of 25-watt bulbs per man-hour was 52.5; in 1931–1932 it was 4,538.9. Thus the index of output per man-hour increased more than 86-fold in little over a decade, and a still more efficient machine, the ribbon-bulb machine, has been subsequently installed.

The technological progress in the electric lamp industry has been paralleled in so many other industries that a serious situation has been created. We have to face the fact that we can produce more and more with fewer hands, and meanwhile the population is continually growing. Even when industry reaches whatever hypothetical normal may be denominated as "recovery," it may still fall many millions short of absorbing our unemployed. Nor can we solve the problem by any "back to the land" movement, for on the farms also the output per man has been increasing. Fundamentally, it is a problem of distribution, a problem of what to do with goods for which there is no profitable sale. It goes against our whole previous training and experience to give away goods and services to idle, able-bodied men, yet this solution seems much more sensible than creating an artificial scarcity. There has been too much uncritical acceptance of the assumption that the crisis is due to over-production. As a matter of fact, if the studies of the research specialists of the Brookings Institution, published in "America's Capacity to Produce" and "America's Capacity to Consume," are valid, we still have under-production, and we have not even potentially the ability to produce in excess of the consumptive needs of our population, if everybody is to attain the much-touted American standard of living. Common sense should tell us that the road to prosperity lies in increasing wealth, not in limiting or destroying it. Let us, therefore, expand our production to the maximum, and if even then we can not employ everybody, we shall be able with the surplus more easily to maintain the unemployed. We need not maintain them in utter idleness; we can set them to a wise use of leisure, such as going to school, and pay them for it. If then they should be regarded as favored individuals, we can rotate the work around, giving people alternate periods of work and profitable vacations.

The third argument in defense of technology is that the jobs which science destroys are the drudging jobs which call for hard muscular labor. Thus science lightens man's toil, but the interesting tasks, which call for the exercise of human judgment, are preserved.

That machinery has lightened human toil is incontrovertible. Nevertheless, the tasks it takes over are not always unpleasant and hard; some of the interesting and skilled jobs are included. Moreover, the work of tending a machine is sometimes very monotonous and so simple that it does not develop the worker either physically or mentally.

Finally, I come to the fourth argument, which is to the effect that the dam-

age done by technological advances is not the fault of scientists, but must be charged against the economists and statesmen, who are inadequate to the task of utilizing the benefits of science, while at the same time repressing its potentialities for evil. Sometimes it is added that the responsibility for this failure rests on social science, which has not kept pace with natural science, and our economic crises are the penalty we are paying for this lag. In other words, by this argument the physical scientist escapes all responsibility for the social results of his research. He says, in effect: I increase the powers of puny man a hundred thousandfold; the use to which you put these powers is none of my business. If unwise use of them creates grave problems, I refer you to the social scientist; perhaps he may have some solution to offer.

There is great misunderstanding as to the nature of social science and as to the sphere of its practical application. In the first place, the social scientist does not have his conclusions accepted without question. The natural scientist can ignore the ignorant and the prejudiced, but the social scientist must attempt the often impossible task of convincing them that certain existing arrangements should be altered or that certain experiments are worth trying. Most people have rather decided views about economic, political and social questions, frequently most stubbornly held by those who are least informed. We have only to recall how the pronouncements of economists have been ignored in framing tariffs and in reference to the reparations and international debt questions to realize that the warnings of social scientists often fall upon deaf ears.

Another difference between natural and social science is that social experiments can not be undertaken merely for the sake of the advancement of knowledge, because a social experiment once launched alters the whole course of history. Any talk about accelerating the progress of social science until it overtakes natural science is pure nonsense. The two are not on the same footing and do not operate in the same realm.

The problem of unemployment very well illustrates the difference. It can never be solved by any technique remotely resembling that employed in laboratory sciences. Any solution which may be proposed is sure to affect adversely some one's interests and so to incur the opposition of human will. An engineer is prone to assume that managing human beings is like managing things; it is simply a matter of inventing the correct set-up. However, in assembling materials he is dealing with objects of known and dependable properties; he never has to contend with any such truculent and incalculable factor as the human will. The fact that we must recognize—which is not sufficiently recognized—is that social engineering (if there is such a thing) can promise us no certain result, that it will necessarily advance haltingly and with many retrogressions, and that since its progress will involve the readjustment of human relationships, it will always be attended by a certain amount of turmoil.

Whether or not the physical scientist disclaims responsibility for the use which is made of his discoveries, he can not escape the consequences as a member of society. The profound alterations made as a result of technological advances are the concern of all of us. It is a matter of vital importance to us all that science should be a blessing, not a curse. A prerequisite to this end is that we shall approach social problems with an open mind, that we shall recognize that a new situation has been created, that we shall discard ancient shibboleths, and be prepared to cooperate, even at some personal sacrifice, in a sincere effort to distribute the social dividend more fairly than it has been in the past.

PECTIN IN NATURE AND INDUSTRY[1]

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AMONG the substances found in plant life and of which little is generally known is a group called pectic substances. These substances are found in the cell wall of plant tissue and are grouped into three general classes termed protopectin, pectin and pectic acid.

Protopectin is the water insoluble, unhydrolyzed pectic substance. This substance is changed to the soluble pectin by treatment with enzymes, acids or other reagents in a variety of ways. Pectin is the water soluble intermediate substance or group of substances found in ripening or ripe fruits. This material is changed by enzyme or chemical hydrolysis and complete elimination of methyl ester groups to the final pectic substance—pectic acid—associated with the breakdown of tissue and decomposition.

The chemistry of these pectic substances has been studied extensively. It is generally agreed that a polymerized galacturonic acid anhydride is the basic unit of pectin and that in addition the compound contains arabinose, galactose, acetyl and methoxyl groups. The size of the nucleus and the amount of other constituents have not been agreed upon, but they evidently depend on the method of extraction and will vary. The latest results give the unhydrolyzed pectin an octagalacturonic acid nucleus.

Braconnot, a French worker, is credited as being the first to extract pectous material from plants. This work was published in 1825, a little over one hundred years ago. He extracted what he termed pectic acid from the roots of several vegetables and from the leaves and stems of plants and trees. Braconnot took the name pectin from the Greek word πηκτις meaning coagulum. As research was conducted down through the past century it became firmly established that pectin was the primary constituent of the middle lamella of the cell wall of plant tissue.

Studies have been carried out on the constitution and extraction of pectin from fruits, vegetables, leaves, buds, twigs, seed kernels, straw, roots, stalks and even from cork. All these sources have pectin in various amounts, some evidently with a slight variation in constitution, but nevertheless a pectous substance. The two largest sources of pectin utilized at present are the albedo of citrus fruits and the pomace of apples.

Pectin is important in every phase of the growing plant. It is found in the root hairs of seedlings. These small hairs have a layer of pectic material on their outside. C. G. Howe in the *Botanical Gazette* for 1921 suggests that the fact that virgin soils yield full crops may be due to the structure of the root hair which enables it to change the difficultly soluble constituents of the soil into food for plant growth. It may be that the medium for this exchange of plant food is the colloid pectin.

Plants normally have pectic substances distributed throughout their growing parts. A change in normal pectic content is generally associated with some disturbance. Disease such as "silver leaf" afflicting apple leaves has been found to be accompanied by a decrease in normal pectic content. After injury to plant tissue by insect attack or bruise, the wound tissue which forms

[1] Published with the consent of the director of the Delaware Agricultural Experiment Station.

contains a greater amount of pectic substances than ordinary plant tissue. E. J. Candlin and S. B. Schryver, English workers, found that as the plant tissues become lignified the pectin gradually disappears, evidently due to decarboxylation to lignin and hemicellulose. However, throughout the succulent, growing tissues of the plant pectic substances are found.

The ability of plants to resist cold and their susceptibility to hardening is dependent upon the water held by colloidal adsorption, according to J. T. Rosa in University of Missouri Research Bulletin No. 48. With an increase in hydrophilic colloid content in the protoplasm of plant cells there is an increase in imbibition. Changes in the acidity of the plant tissue are also responsible for changes in the water-retaining power of the colloids present.

In the fruit itself, pectin seems to have an important part in the growth and ripening. We happen to be the most interested in the pectic substances of this product of the plant because it is from the small, inferior or surplus fruit we wish to extract pectin for commercial use.

In the case of the apple, in the early stages of ripening no soluble pectin is found. As ripening proceeds the pectin gradually changes to the soluble state. The presence of soluble pectin reaches a maximum which coincides with ripeness of fruit and then, as the fruit changes from the ripe to the over-ripe condition, the pectin content decreases with a corresponding increase in its decomposition products.

Since we are dealing primarily with the uses of pectin we will only stop momentarily to mention that the extraction and recovery of pectin from the fruit or plant source is carried out with the idea of converting the proto-pectin to the soluble pectin without an accompanying decomposition of the pectin. Heat and acid are usually applied to extract the material. Other methods specify extraction by electrodialysis, by osmosis or by enzyme action. The extract finds its way to market in a concentrated product as a liquid, a dry powder or a film. The extraction, recovery and preparation of pectin for the market is a complex subject. Many patents have been taken out specifying various methods of processing.

Since pectin is most familiar as a jellying agent let us consider its use in jelly and jam manufacture. It is used for making up the synthetic pectin-sugar-acid jelly of special flavor and color, such as mint jelly. It is required to jelly bottled juices where the original pectin has been destroyed, either intentionally or not, in the preparation or storage of the juice. With some fruits where the pectin is naturally low or where the extraction treatment has been too severe more pectin must be added for jellying purposes. The jellying properties of any fruit juice depend upon the quality and quantity of its pectin content and its pH (active acidity). The pectin characteristics can be determined by measuring the viscosity of the solution. The optimum acidity is very hard to determine, and actual trial of the quantity of acid needed is the only satisfactory method. By measuring the viscosity of a fruit juice extraction an indication of the sugar-holding capacity is obtained, provided the acidity is adjusted to the optimum, which will be found in the neighborhood of a pH of 3.

There are certain advantages in using pectin in the preparation of jams and jellies. The amount which need be added is relatively small—if a purely synthetic product is made from a 100-grade pectin only 0.65 per cent. pectin need be used at the most. In cases where the fruit is only slightly deficient in pectin, very small quantities need be

added. When pectin is added jam or jelly can be made with any available fruit. It is also possible to cut down on the cooking time if the pectin quality is good, because a larger pectin content will support more sugar and less water has to be evaporated. Thus a lighter-colored and generally more attractive product is obtained. Since more sugar may be added the yield of jelly is increased and the cost of the product reduced. Of course this must not be done with any sacrifice of flavor. The viscosity method is really the only reliable way to tell whether more pectin should be added to fruit-juice extractions, because by this method you have definite figures of the sugar required and the final weight of jelly to be produced.

Many patents are issued on the manufacture and preparation of pectin to be used as a jelly base. The liquid pectin is quite familiar to the public. The dried pectin is becoming better known. Combinations of sugar, acid, salts and pectin are mixed up with the hope of easy solubility. Pectin alone has a tendency to clump, or ball up, when put into solution. By adding a carbonate or bicarbonate and an excess of acid to the pectin base when the product is put into water effervescence occurs and the pectin particles are held apart so that they disperse more readily. Particle size influences dispersion also. The acidity of these preparations is regulated so as to compensate for the lack of sufficient acid in certain fruits.

The use of pectin in the manufacture of cranberry jelly seems rather unnecessary since cranberry has such an abundance of this material. However, a late method specifies the destruction of the natural pectin by a pectinase, a pectin-decomposing enzyme and the addition of commercial pectin to replace it. The value of this procedure lies in the fact that the amount of pectin added can be controlled. There is apparently much more research which could profitably be undertaken on the subject of cranberry jelly.

In close association with the use of pectin in jam and jelly manufacture is its use as a thickening agent for soda-fountain syrups and crushed fruits. Pectin on account of its jellying characteristics makes a thick, heavy syrup which tends to stay on top of the ice cream and gives an impression of richness to the consumer. More body is imparted to the sodas which are made up with these viscous syrups.

While we are considering sweets, we must mention a new "gum drop" with pectin jelly center which is having good sales. These candies can be made up with ease and keep fresh without turning sticky or hard. When made right they are tender and firm, and when bitten into are of a brilliant sparkling color. They make a very attractive showcase display. Pectin also produces a firmer apple concentrate candy, the famous Virginia product.

Tomato juice for cocktails and catsup are benefited by added pectin in that it makes them more viscous, which improves their physical appearance. Pectin also increases the resistance of the product to separating into layers of pulp and liquid.

Pectin has been added to fruit juice intended for beverage purposes previous to spray drying. In such an instance pectin acts as a carrier which helps to hold fruit essences and gives the syrupy characteristics demanded by the beverage consumers. It also prevents agglomeration of the solids present. Other beverage bases utilizing pectin are combinations of milk, pectin and fruit juices dried together.

It is said that pectin improves the texture, yield and moisture-holding capacity of baked food products. The staling process in these foods is definitely slowed up. This use may easily be abused by

trying to introduce too much moisture, so much so that the total solids content is lowered abnormally and aging is accelerated. In connection with the baking industry, pectin improves the texture and time of set of meringues and frostings.

In dairy products, such as milk, pectin acts as a protective colloid and has a definite stabilizing action. Similar to gelatin it improves the texture of ice cream. The incorporation of a small amount of a stabilizing colloid such as pectin in cream cheeses and those of the "club" type allows the heating of the cheese to kill organisms naturally causing rapid deterioration. The colloidal matter preserves the normal body and texture of the cheese through this heat treatment.

The use of pectin in foods is considered beneficial to the digestive system; similar to malt it acts as a protective colloid. In Germany, Dr. Kurt Imhauser introduced 30 to 50 gram portions of dry citrus pectin in water to the stomach of several dogs. He found that the blood sugar did not go up definitely but showed only slight variations with no definite trend. He also found that pectin given to phloridzinized dogs did not protect the liver from fatty degeneration, which means that there are no utilizable carbohydrates derived from pectin. The administration of 30 grams of pectin to a dog reduces the amount of acetone bodies in the urine—showing an antiketogenic effect, galacturonic acid being a possible source of this action. Thus pectin may be considered safe even for inclusion in a diabetic's diet.

Pectin is an excellent constituent of pharmaceutical preparations on account of its high viscosity and colloidal properties. It is especially valuable as an emulsifying agent in such preparations as emulsified castor oil. It is used in hand lotions and hair dressings. However, its usage in the pharmaceutical field has been kept more or less secret.

Rooker suggests the use of pectin as a glue or mucilage on account of its adhesive characteristics. This can only be accomplished by the use of preservatives. That it is too expensive to compete with materials of this type is acknowledged. The price of pectin is admittedly high, but with an increase in the uses to which it may be put, new methods for producing this product will be developed. A larger demand will allow larger units of production, all of which will tend to lower costs.

In connection with the textile industry ways and means of getting rid of the pectin are usually sought. The retting of flax and subsequent fermentation is a process involving the destruction of the pectic material present so that the tissues may be more easily macerated and the fibers separated. A combination of anaerobic and aerobic organisms or various fungi which secrete pectic decomposing enzymes are used for this purpose. Four to eight per cent. of pectic material has been reported present in flax stalks. If this pectin is not removed, cloth made from the fiber will be discolored after long storage or by washing in alkali. The tensile strength will also be impaired.

Comparative tests of the use of pectin (from beets) and of starch for finishing textiles reported by Lyubimov (from abstract in *Chimie et industrie*) have shown that: There is practically no difference as regards the strength of the warp. The pectin treated fibers can be worked as well on Platt looms as on Northrup looms. The pectin treatment is much the simpler. Satisfactory results are obtained with pectin, even without the addition of auxiliary substances such as glycerol, soap or tallow, generally used in conjunction with starch. The use of 7 per cent. pectin is sufficient to dispense entirely with starch and is much cheaper.

Russian and Japanese investigators have associated pectin and tobacco qual-

ity. In cigarettes, the pectic content varies between 9 and 20 per cent. and, in cigars, between 13 and 15 per cent. The poorer the quality of tobacco, the higher is its pectic content. This pectin, present as calcium and magnesium pectate, is claimed to be similar to flax pectin. The fermentation process is stated as having no effect on the pectin content. Probably the pectin goes to pectic acid because there is a loss of methoxyl reported during the period of curing and fermentation. Pectin is the chief source of this methoxyl. The loss of methoxyl during fermentation is reported as small in high-grade tobaccos. In the tobacco plant the content of pectic material and methoxyl is higher in the upper leaves, reaching a maximum in the top leaves.

In the sugar industry, small amounts of pectin are extracted due to the presence of pectin in both the beet and sugar cane. In the fresh beet pulp there is about one per cent. pectin, and there is about the same amount in cane fiber. Assuming that the pectin is left in the juice it would amount to about 0.15 per cent. in the molasses when a process of extraction of the sugar by diffusion is used. Ehrlich claims that during liming of the juice polygalacturonic acid is formed which is precipitated as the calcium salt. Farnell says that experiments show that neither by acid nor alkali clarification nor by hot or cold liming are any appreciable amounts of the pentosan removed.

According to Semichon and Flanzy, pectins present a means of distinguishing natural liquor wines obtained by over-ripening and sun-drying of grapes from liquor wines obtained by artificial concentration of the must. The pectins in natural wines are much higher. The pectin content varies with different wines. Grapes which sun-dry readily give musts rich in pectin and mellow wines. Those which do not dry readily give musts low in pectin and dry wines, lacking mellowness. Dry wines can be mellowed by heating fresh grape skins with part of the must. This converts the protopectin of the skins into soluble pectin. The mellowness is credited to be favored by the dissociation of the methyl pectic ester and the combination of the methoxyl with the essential oils and oleoresins contained in the grapes.

In unfermented juices, such as grape juice and apple cider, it has been found that clarification produces a clear, brilliant juice. Pectin, as a colloid, aids in the suspension of other material which clouds the juice. Several ways of decomposing pectin are employed which aid in clarifying the juice. Flash heating (the application of heat to raise the juice to 180° F. for 20 seconds), use of another colloid, such as casein or gelatin, and use of enzymes secreting pectase have been tried to accomplish this purpose. The pectin is converted into soluble substance or flocculated and filtered off. By adding pectin to juices, just the reverse of the above process is accomplished. Juices so treated may be made to appear as though freshly extracted.

Small amounts of pectin in solution aid in crystal growth, according to Ehrlich. Long pointed crystals of ammonium chloride, weighing several hundred grams and a meter long, were obtained. Similar enlargement of crystals of ammonium bromide, ammonium sulfate, potassium chloride, potassium nitrate, barium chloride and boric acid were obtained.

In the use of pectin as an emulsifying agent for tree sprays, we find pectin being applied to the fruit from which it is eventually obtained. This use is negligible at present, owing to the high price of the commercial pectin. The application of preservative surface coatings of oils and waxes on fruits incorporating pectin as an emulsifying agent has been suggested.

Patents covering the use of pectin in the so-called "creaming" of rubber latex have been issued. Certain hydrophilic colloids when added to rubber latex cause the latex to separate into two layers similar to the separation of cream from milk in the dairy industry. The portion corresponding to skim milk contains water and serum made up of proteins, sugars and other impurities. The portion corresponding to the cream is higher in rubber particles by an amount in proportion to the degree of creaming. This creaming is caused by the colloid surrounding the rubber particle and causing a slight change in the specific gravity of the particle. With the equilibrium upset, the rubber particles tend to form an upper layer. After drawing off the serum the "creamed" layer is subjected to a hydrolyzing action which decomposes the pectin. A saving on shipping costs is readily seen by this process as well as a product containing a lower percentage of non-rubber constituents.

A new use for pectin which holds out possibilities of large consumption is the hardening of steel by pectin solutions. It is claimed by Ripa that the heat conductivity of pectin solutions is approximately the same as that of oils ordinarily used for the quench hardening of steel. Varying degrees of hardness may be imparted to the steel by varying the concentration of pectin, which, of course, can be easily adjusted to any concentration in water solution. Concentrations of 0.5 to 15 per cent. pectin (dry) in solution are specified as having been used. A low concentration of pectin produces a very brittle and hard steel. Tool steel, a hard, tough product, requires about a 4 per cent. solution. Among the advantages of pectin solutions over oils for this purpose are: easy regulation of heat conductivity, non-combustibility, one operation for the hardening and tempering, and favorable competition on a price basis.

Naturally, it is only with large-scale usage and a cheaper cost of production that other uses will be presented. A recently suggested use for pectous substances is as a condensation product. Such a use would call for quantity production. The sources of the pectin substances for this use are from such materials as cereal straw, flax, hemp and corn stalks. The pectic liquor, extracted by heating these substances with water or steam, is filtered off and evaporated to a heavy, viscous, dark-brown residue, similar to heavy molasses. By reacting this pectous residue in the presence of formaldehyde and a condensing agent under such conditions as to initiate an exothermic reaction under regulated conditions an intermediate condensation product is obtained. This intermediate product, a thinly viscous material, is soluble in water or other volatile solvents. Allowed to stand exposed to the atmosphere it will become insoluble but still retains its properties of fusibility. This intermediate condensation product may be used as a saturant for fibers or fabrics, and with application of pressure and heat, in the production of a hardboard product.

By reacting the pectous residue in the presence of an aldehyde and a ketone, using an alkali as a condensing agent, a resin is produced having many of the characteristics of the phenol formaldehyde resins.

A plastic composition adapted to serve as an impregnating material in the lamination of sheets of fibrous material is also obtained from the pectous residue. This type of plastic is obtained by adding an excess of a ketone as a retarding agent to prevent the intermediate stage of condensation from progressing. Upon adding a hardening agent such as hexamethylene tetramin and heating the mass infusibility and insolubility are induced. This composition may be used as a binder for abrasive substances, composition wood and the like. In the final

stage it is claimed that it is infusible and insoluble in such solvents as acetone, amyl acetate or ethyl alcohol, and very resistant to the action of acids or alkalies.

These various uses for pectin are naturally only worthy of development if they can compete with established products on a price basis. We have in pectin a product of definite colloidal properties of high viscosity and high emulsifying power. With further knowledge of the properties of pectin and pectic materials it can well be assumed that other uses will be found. It is hoped that enumeration of present uses will create more interest and suggest new uses for pectin that it may be a greater source of profit to the orchardist and manufacturer of the future. At present, only a small portion of the waste fruit out of a total annual production of over 150,000,000 bushels of apples reaches the cider press. In turn, only a fraction of the pomace which is dumped from the cider mill finds its way into a more complete recovery of by-products in the extraction of pectin.

LOCATING PROPERTY BOUNDARIES

By Professor S. S. STEINBERG

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It is generally admitted that the widespread ownership of land is one of the important factors making for the stability and well-being of the nation. It is likewise generally known that boundary disputes between nations have frequently led to wars, and such disputes between private owners of property have led to ill-feeling, confusion, litigation and loss of money. Therefore, anything which contributes to the security of land tenure, reduces its costs and makes for cordial relations between neighbors, whether they be nations, states or individuals, merits careful and sympathetic consideration. Land being one of the most important things that the human race owns, it is essential that the custodian of a piece of property, whether public or private, should know where the boundary lines are.

Land surveying, the art of measuring land and of delineating its boundaries on a map, is generally supposed to have had its rise among the ancient Egyptians, due to the river Nile's destroying and confounding all their landmarks by its annual inundations. This put the Egyptians to the necessity of inventing methods and measures to enable them to distinguish and adjust the limits of their respective grounds when the waters were withdrawn. The Egyptians, in addition to being the first to measure the earth, likewise were the first to determine the relations between the heavenly bodies. Their knowledge of these matters was engraven on columns and by that means delivered to posterity. It is interesting to note that the modern engineer or surveyor makes astronomic observations for use in all important mapping as did his predecessor in early Egypt.

The present system of locating property boundaries is based on the belief that a point on the earth's surface can be perpetuated by placing on it some physical object for a marker. Many centuries ago the Egyptians learned the fallacy of that theory, but we still adhere to it. In a recent city improvement, a boundary monument of massive concrete was lifted out of the ground by a steam shovel even before the engineer could reach a tape to it to locate its

former position. If a monument like this is impermanent, what hope is there of an enduring future for the stake, the pile of rocks or the blaze on a tree, which commonly mark farm boundaries?

It might be of interest to cite from an old deed the description of the starting point of a tract of land which read, "Beginning at a point on Powder Mill Run where Bill Jones killed the Indian." Needless to say, that corner could not be found. Also, there are many cases where excellent surveys have been of only temporary value because the surveyors making them left no permanent monuments.

There is nothing that causes more trouble to an owner of a piece of property than to have doubt raised as to the exact location of his land. He may wish to sell the land and give clear title to it, or he may wish to raise money on it. In either case he must be certain that the exact locations of his boundaries are known. His boundaries will be known if he has placed substantial monuments at their turns, setting the monuments in such a way that they are not likely to be disturbed by man or nature. A small amount of concrete, properly placed, will make an excellent mark, and to establish such a landmark will cost an insignificant amount compared with the cost of doing the survey work over again.

Landmarks have been the subject of legal action for thousands of years. Back in the time of Moses, in 1500 B.C., the laws protected survey monuments. One of these laws read: "Cursed be he that removeth his neighbors' landmarks, and all the people shall say Amen." Job, in speaking of the wrong-doing of his people, listed the removal of landmarks as one of the reprehensible acts they committed. Solomon, in his Proverbs, said, "Remove not the ancient landmarks which thy fathers have set."

In the United States, during Colonial times, with land plentiful and population very scarce, only the crudest kinds of surveys were made on the outlines of a grant from the King or the Colonial governor. After the Revolution, with the western area of the country opening up for settlement, a method of laying out the public lands in squares approximately one mile on a side was adopted. The land there was plentiful and it was not feasible to use exact surveying methods in establishing these township range and section lines. To have done this work in an exact way would have made the cost excessive as compared with the value of the land.

The early surveys were notoriously inaccurate. Practically all the surveying was done with the compass and the chain. Measurements of angles and of distance were made by methods that were crude and unreliable, and frequently no account was taken of the magnetic attraction of the earth on the compass needle. Finally, it was the common practise not to close the circuit of the property boundaries. There are many deeds on record in which a description encircles the greater part of a tract and, having run to a spot somewhere in the vicinity of the starting point, closes with the charitable phrase, "and thence to the place of beginning."

Because of these inaccuracies, it has come to be the well-established court practise that the actual positions of the boundary marks on the ground, if they can be established with reasonable certainty, will control rather than the metes and bounds as given by the surveyor.

Conditions, however, have changed with the years, and land that was originally worth a few cents or a few dollars an acre may now be worth a hundred or even a thousand dollars an acre. In some of the large cities, lots are worth thousands of dollars a square foot. This increase in the value of land necessarily calls for an increase in the accuracy

with which the boundaries of the land are surveyed. The engineer's transit and the steel tape have replaced the compass and the chain.

In addition to the thousands upon thousands of conflicting private property boundaries, there are scores of state boundaries in the United States which have been subject to controversies in the past or may at some future time require redetermination. It is a general legal principle that when a boundary is once accepted by the custodians of abutting properties, it is the boundary for all time to come. But the question arises: "How can a boundary be so located that it might be easily recovered in the future?"

An answer to this question is furnished by the Geodetic Control Surveys that were conducted in Maryland during the past winter under the auspices of the United States Coast and Geodetic Survey and in cooperation with the College of Engineering of the University of Maryland. Similar projects were undertaken in the other states. They were financed by the Civil Works Administration as a means of employment for engineers and for the performance of a work of great economic value to the people of the states. Some 420 Maryland engineers, surveyors and assistants, operating in all sections of the state, were engaged in establishing control lines and elevations which provide a basis for accurately tying in land surveys in the future. In addition, these points serve as fundamental control for all engineering projects that might be undertaken in any community.

In conducting the control surveys the general practise is to follow the improved highways, since the aim is to establish points in places readily accessible. The monuments used are three-foot concrete posts which are set flush with the ground at the edge of the road right-of-way. The monuments set west of Frederick were four feet in length, due to lower frost line. The top of the monument has a bronze cap on which will eventually be stamped the number of the marker and its elevation above mean sea level. Monuments are set in pairs one quarter of a mile from each other, with each pair about two miles apart. They are established in every town on the circuit and at important crossroads, so that engineers will have these reliable points for referencing any survey or engineering project in that vicinity.

In establishing these monuments extreme accuracy of measurement is required. Distances are determined with a steel tape which has previously been compared with a master tape standardized by the National Bureau of Standards. The tape is stretched carefully between special chaining tripods, and in stretching it a spring balance is used at one end to make certain that the required tension is given. At the time of each tape measurement a thermometer reading is taken so that correction may later be made for increase or decrease in length of the tape due to temperature. All distances and elevations are determined to the nearest thousandth of a foot.

These control surveys have a real value to every owner of land, whether of a farm or a city lot, because a land survey which has been tied into such geodetic control is indestructible. Should every point of such a survey be lost or destroyed, the property boundaries can be retraced and the old points relocated. This is possible because the geodetic control is part of the triangulation network which has been established throughout the country by the United States Coast and Geodetic Survey in the past hundred years of its operation. Any survey so referenced becomes tied into the geography of the United States, and as there is only one point on the earth's surface

that has a given latitude and longitude, that point can be recovered at any time in the future.

To facilitate surveying of counties and other local areas, computations have begun, as part of the Civil Works Administration project, on a system of referencing points in Maryland which will eventually permit coordination of land or engineering surveys in the state. At present at least three separate and unrelated groups of surveys are in use in Maryland; namely, those in Baltimore, in Annapolis and in suburban Washington. When the single coordinated system for Maryland is fully computed it will be a comparatively simple matter to have these three different units referred to the state-wide system and thereby facilitate surveying operations between those three cities and, also, its extension to the remainder of the state.

It would be advantageous for each state to have a land court, in which all disputes over property boundaries could have a hearing. Since laws relating to the ownership of property are very complicated, it is reasonable to expect that such a court, concentrating on boundary matters, could render decisions more expeditiously than one not so expert. Massachusetts has had a land court for some years. There the law requires that private property boundaries be connected with the control system of the state. The township lines were definitely located and tied into the Coast and Geodetic Survey network and monuments were set upon these lines, thereby making them available in that state to any engineer or surveyor who undertakes a boundary survey.

One of the newest developments in land surveying is the use of the airplane for taking aerial photographs. With geodetic control monuments on the ground serving as a ''yard-stick,'' maps can be constructed with little difficulty from the assembled photographs. This method, which speeds the work and reduces the cost, has been found very useful in locating boundaries of large tracts of land, in city planning and in mapping inaccessible areas. The land areas in Baltimore and in the vicinity of Annapolis have been surveyed from the air, and the resulting maps have been found extremely valuable in defining property boundaries and for many engineering purposes. By means of aerial photography in certain states, parcels of land have been discovered that were not previously listed on the books of the tax assessors.

All Europe, Mexico and many countries of South America have accepted geodetic control, and in those countries it serves as a foundation for all surveying, whether public or private.

As a result of the impetus given to this work last winter under the Civil Works Administration, it is hoped that sufficient funds will be forthcoming for the extension of this project in all the states to a point where geodetic control would become generally available for use by engineers and surveyors in their work, and particularly in so locating boundaries as to avoid overlapping of adjacent properties. Boundaries that are connected with geodetic control are really tied to the stars; and, as the motions of the heavenly bodies are immutable, so, by the use of this system, will property boundaries become definitely established for all time.

POLLEN GRAINS AND WORLDS OF DIFFERENT SIZES

By Dr. R. P. WODEHOUSE
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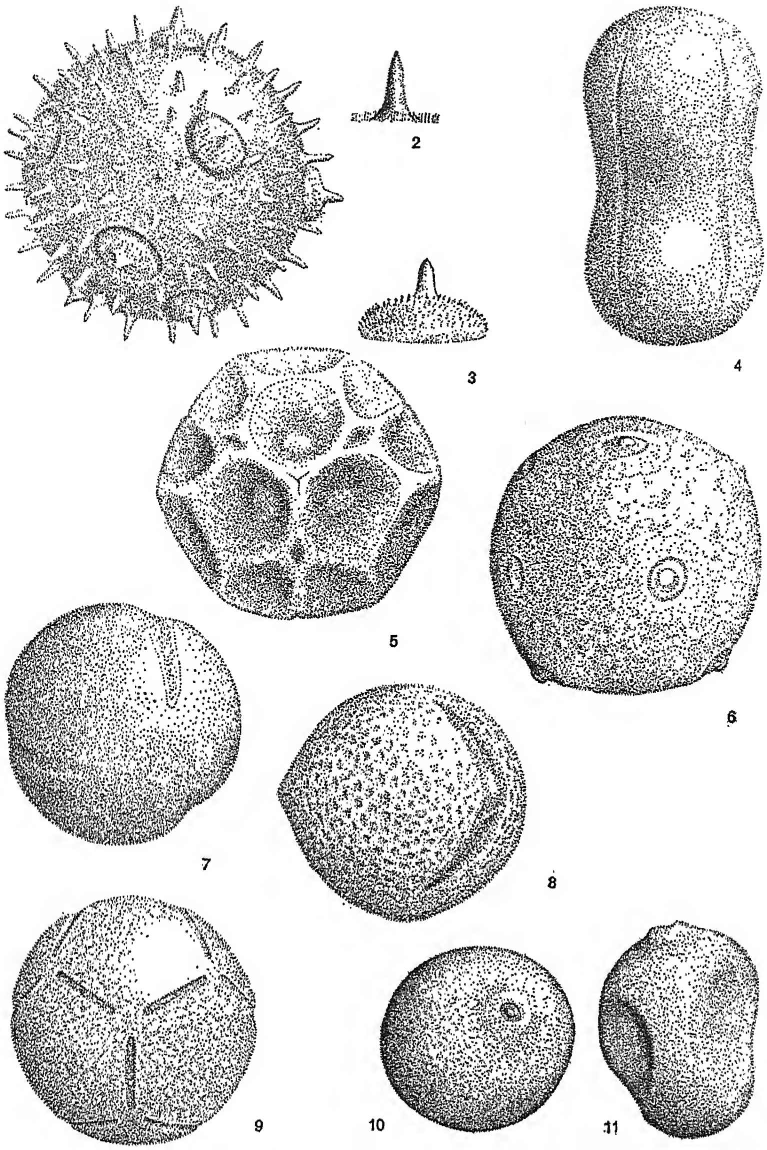
Perhaps the first question that one is going to ask himself upon approaching the subject of pollen morphology is: Why are the forms of pollen grains so odd and strange—so different from the things that we are accustomed to seeing in everyday life? It is true they are not all alike; unrelated species can easily be told apart, and often the differences between them are very great. Nevertheless, great as these differences are, they are trifling as compared with those that exist between pollen grains and the things that we are accustomed to seeing without a microscope. The microscope shows us another world. And truly this is the answer to our question. Pollen grains belong to a world of another size.

The World of Gravity Walkers

There is a law of nature which places a handicap on bigness; the larger an animal is the greater the difficulty it has to move. Mathematicians have a more exact way of stating this law. They say the surface or cross-sectional area of a thing is a function of the square of its linear dimensions, while its volume is a function of the cube of the same dimensions. Among the everyday things that we know, this disproportionate increase of volume or weight over area that is encountered in an object increases in length and breadth, limits the size of animals which, for example, may walk comfortably bearing their weight on their feet, to about the size of an elephant. Animals very much larger, like the whales, must live in an aquatic medium that supports their bulk, for it would be totally unmanageable on land. At the other end of the series, a mouse is perhaps the smallest animal that has weight enough to get traction for its feet, and even it freely uses its claws for that purpose. This is the world of our size, bounded at the top by about the size of an elephant and at the bottom by that of a mouse. It is the world in which we perform most of our activities and to which we are best adapted. We need no lenses to see all of it and we need no mechanical aids to handle things in it, hence our feeling of being at home in it.

In this world of elephants, men and mice, animals walk on four or two feet, and the bearing of their weight, particularly among those near the upper limit, is perhaps their most serious structural problem. All beings, both plants and animals, which inhabit this size world, are primarily shaped by the asymmetrical or one-directional pull of gravity. The plant directs its stalk upwards against the force of gravity and its roots downwards with the force of gravity, while its branches may be symmetrically arranged around the vertical axis; and for the same reason animals differentiate an upper and lower side. But the forces of this size world tend to impose a further limitation of symmetry on all beings in it which move, for in response to a motion which is always at right angles to the gravitational pull, front and back ends are likewise clearly differentiated. Nature's tendency to make all things as symmetrical as possible is thus thwarted in all directions, except laterally, but here it asserts itself. Thus it is that beings which move in this world are



HIGHLY MAGNIFIED POLLEN GRAINS

THAT OF THE FORGET-ME-NOT AT THE SAME MAGNIFICATION AS THAT OF THE SQUASH IS ABOUT AS BIG AS ONE OF THE SPINES OF THE LATTER. (1) SQUASH (*Cucurbita Pepo* L.), 150 μ IN DIAMETER. (2) A SINGLE SPINE OF THE LATTER MORE HIGHLY MAGNIFIED. (3) ONE OF THE CAPS OF THE LATTER MORE HIGHLY MAGNIFIED. (4) FORGET-ME-NOT (*Myosotis sylvatica* HOFFM.), 6.8 μ LONG. (5) *Oryctanthus botryostachyus* EICHL., 34.2 μ IN DIAMETER, A MEMBER OF THE MISTLETOE FAMILY. (6) PLANTAIN (*Plantago lanceolata* L.), 35 μ IN DIAMETER. (7) ST. JOHN'S WORT (*Hypericum perforatum* L.), 10 μ IN DIAMETER. (8) COMMON ELDER (*Sambucus canadensis* L.), 18.2 μ IN DIAMETER. (9) MOUNTAIN CORYDALIS (*Capnoides montanum* BRITT.), 26 μ IN DIAMETER. (10) TIMOTHY (*Phleum pratense* L.), MOIST AND EXPANDED, 37.5 μ IN DIAMETER. (11) THE LATTER DRIED AND SHRUNKEN.

characterized by a right and left, or bilateral symmetry. It is the only one possible to them.

Among animals which move in this world flight is seldom undertaken and is hazardous, except towards its lower limit. It may be called the world of gravity walkers. Within it forms of things may be very different; yet, when compared with those of either the world of larger things, which is perhaps the world of planets and solar systems, or with those of the world of next smaller things to which the insects belong, they seem much alike.

The World of Easy Flight

Within this world of smaller things gravity and movement impose the same type of bilateral symmetry, as before, upon the beings which inhabit it, but its lessened effect brings about some curious results. The support of bodily weight is not a problem; instead, the effect of gravity is too weak to give sufficient traction for convenient walking on four or two feet in the usual way. Feet must be provided with suction disks or with hooks. In this world of lessened gravitational effect it is nearly as easy to walk across a ceiling or up a vertical wall as it is along the floor. In it flight is the rule and not the exception, and it is attended with no hazards. So much is this so that it may be called the world of easy flight. It is a world in which we are not at all adapted and can play no part without special aids. Even for us to observe most of it a good lens is a help, and to handle objects in it forceps and other instruments are necessary. Among its inhabitants insects predominate, for their structure, which is far different from that of elephants, men and mice, is beautifully adapted to movements within its size limits.

Though the effect of gravity is so far reduced that flight is easy, its accomplishment requires muscular effort. Only the smallest inhabitants of this size world attempt to float without muscular effort, and when they do they must devise some special floating mechanism, such as the tuft of silk of the balloon spider or the crown of pappus of the thistle seed.

World of Floating and Sticking

In the next smaller size world, the one to which spores and pollen grains belong, floating is easily accomplished. No wings are used, because none is needed. It is a world of objects so small that when they are free they float, for the effect of gravity is not strong enough to pull them down against the slightest current of air, and when they touch they stick, for the effect of gravity is not strong enough to pull them loose again. But the lack of gravitational effect has an even more important influence, that is, upon the symmetry of the beings of this world; as a consequence of it, their top and bottom sides are not differentiated. Moreover, they do not have any independent forward motion with its consequent differentiation of front and back ends, and they are therefore rarely bilaterally symmetrical, and when they are, it is for reasons of another category. With organisms of this size world, symmetry, which in nature tends ever to be as complete as possible, has much fuller sway and reaches a much fuller expression. Since the sphere is the most perfectly symmetrical figure, it is not surprising to find that beings of this world are basically spherical; it could, indeed, be called the world of spheres. This is, perhaps, the most outstanding character of pollen grains—they tend to be spherical and their sculpturing is nearly always of a much higher order of symmetry than the bilateral, to which we have become accustomed in our world and in the world of easy flight. Is it any wonder that the forms of pollen grains look odd and strange to us?

The range in size of pollen grains does not exactly coincide with the range of the world of floating and sticking. It extends perhaps a little beyond at the upper end, but falls far short at the lower, for there are spores which are far smaller than pollen grains and still float freely in the air. The largest pollen grains, as, for example, those of the pumpkin which are about 200 μ in diameter, are so large that they can not float easily, but they can stick, with the help of a little oily adhesive, so they travel by sticking to insects. From this size pollen grains range downwards to about that of the forget-me-not, which is three microns in diameter. But it too travels by sticking to insects. It is an interesting fact that among pollen grains, only those of intermediate sizes are the best floaters. Invariably both the very large and the very small are exclusively stickers. Only those between fifty-eight and seventeen microns, with one notable exception, are good floaters. The reason that those above this range are exclusively stickers is obvious—they are just a little beyond the size range of easy floating, but still within the range of moderately easy sticking. But the reason that those below this size range are also almost exclusively stickers is not so easy to see. It may be that their small size, with its attendant disproportionately large surface area, is a hindrance to them in leaving their anthers or in separating from each other. That this is so seems likely from the exceptional case of the pollen of the paper mulberry. It is air-borne, yet its grains are only thirteen microns in diameter, which is well below the size range of most air-borne pollen. It is, however, forcibly ejected from the anthers in a rather spectacular manner. If a flowering branch of the paper mulberry is kept in water its pollen will be seen to puff out from the flowers, like puffs of smoke, over a long period of time. Also many fungi, whose spores are even smaller—yet are floaters *par excellence*—are provided with an efficient mechanism for throwing the spores clear of the plant and of each other. The reason that only moderately large pollen grains are floaters is probably to be found in the inability of most plants to develop a satisfactory ejecting mechanism.

Resemblances of Pollen Grains to Protozoa

Many people have marveled at the resemblances between pollen grains and such minute aquatic organisms as the Radiolarians and Heliozoa. The shells of these animals are generally made of some silicious or calcareous material, chemically entirely unrelated to the exine of pollen grains, yet they appear to bear a quite remarkable resemblance to them. Their basic form is spherical and their sculptured patterns are similar to those of pollen grains in their symmetrical completeness. The question naturally arises: How do these organisms come to resemble pollen grains, since their shells are of an entirely different composition and they live in an aquatic medium? The resemblance that they bear to pollen grains is due solely to the fact that they live in a similar size world. They are floaters and stickers without independent movement in an aquatic medium, just as pollen grains are in an aerial medium. And, freed from the asymmetrical influence of a one-directional gravity, and a one-directional movement, they have become as nearly perfectly symmetrical as pollen grains, assuming the spherical form and somewhat similar sculptured patterns. Looked at more closely, however, it is seen that the resemblance is no more than this. Their sculptured patterns are composed of different elements of symmetry, belonging to different mathematical series. For example, the underlying series among the patterns of pol-

len grains is that of the tetrahedron, cube and pentagonal dodecahedron, always with three equal angles coming together at a point; while the patterns of the most similar protozoa, as for example, *Circoporus* and *Circogonia,* are built on the plan of the octahedron and icosahedron, which require four angles coming together at a point, a condition which is never encountered among pollen grains. Such differences as these are basic and, measured in terms of the world of floating and sticking objects, are far greater than—let us say—the difference between a man and a crocodile, measured in terms of our world of gravity walkers.

The actual similarity that all the inhabitants of the world of floating and sticking bear to each other is due to the fact that within the size limits of such tiny objects as spores, pollen grains and protozoa, much less diversity of form is possible than within the worlds of larger objects. It is true that at its upper end and, in fact, through the greater part of its range which is occupied by pollen grains, considerable diversification of form is possible. The large pumpkin pollen grain, those of the Malvaceae with a diameter of about 153 microns, and of the four o'clock, with a diameter of about 180 microns, are elaborate and beautiful objects. Nowhere among the grains of smaller orders of magnitude do we find anything approaching the multiplicity of their detail and beauty of pattern. And as we pass downward in the series of grains arranged according to their size, they become less and less ornate. The smaller pollen grains are practically without decorations, excepting germinal apertures of the simplest kind, or germinal furrows of an equally simple kind, and as we pass over into the domain of spores which are still smaller, even these are missing. Indeed, the smaller spores in their simplicity and plainness of form are quite like bacteria, which are the inhabitants of the next smaller size world.

In the world of bacteria and organisms of similar size the forms are all so simple that it is difficult to distinguish most of them by their morphological characters. For that reason the bacteriologist must rely mainly upon physiological characters for purposes of classification and identification.

We will not dwell longer upon this size world, nor upon those which lie still lower in the scale, than to point out that as the size of the particle diminishes and, as a consequence, the proportion of the surface area increases, new and unfamiliar properties are encountered and the old familiar ones lost. For example, the next size world below that of bacteria is perhaps the world of colloid chemistry. In this world particles are too small for us to see even with a microscope, but if we could see them they would probably be found to be perfect spheres and all look much alike. The properties which distinguish colloids are mainly those which have to do with surface areas, for truly this is a world of enormous surface areas.

A consideration of objects and organisms of these different size classes furnishes a suitable background against which to view pollen grains. Their most striking and fundamental characters are those of the size class to which they belong, and do not lend themselves to ready comparison with objects of other size classes. And underlying this is the old familiar law which says that the surface or cross-sectional areas of an object are functions of the square of its linear dimensions, while its volume is a function of the cube of the same dimensions.

ECLIPSES AMONG ANCIENT AND PRIMITIVE PEOPLES

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SCIENTIFIC researches teach us how to predict solar and lunar eclipses as they also tell us why and how eclipses are caused, but the primitive man laughs at such simple explanations and shakes his head; he knows better than to place his reliance on such fantastic explanations as the scientists would have him believe. No, the true reason for these phenomena is to be looked for elsewhere.

Primitive man peoples the universe with a host of malevolent beings whose chief delight in life is to frustrate the hopes and aspirations of poor mortals, their enemies. The earth, the sky, the waters, nay, even the trees in the forest and all things that the earth contains, has its own particular demon, always ready to swoop down and do whatever damage it can do to human beings. How numerous these demons are it would be impossible to mention in a limited space. Sir James George Frazer, in the twelve volumes of his "Golden Bough" and in other writings, has collected a mass of data from all parts of the world, and a perusal of his works convinces us that these demons are not the exclusive property of any one race, but was, and perhaps is even to-day, the common heritage of mankind.

In the book of Genesis we read: "And God made two great lights, the greater light to rule the day, and the lesser light to rule the night." The lesser light, the moon, has been the favorite theme of poets all over the civilized world; but the greater light, the sun, inspires life. It does not need a physicist to make a man realize the benefits of sunlight and the warming rays. Man seeks these intuitively. When Alexander the Great asked Diogenes what he could do for the philosopher, the latter remarked, "Step aside, and do not shut out my sunlight."

The beneficial effects of the rays of the sun were recognized very early in human history. It was natural, therefore, that some demon would try to shut out the health and life-giving rays, and thus cause a solar eclipse; and perhaps identical ideas actuated these demons to cause lunar eclipses. Various superstitions too are attached to eclipses. The belief that eclipses are caused by demons or beasts devouring the luminaries is to be found among the Chinese, the Hindus, the Greenlanders, the Finns, the Lithuanians, the Moors, many North and South American Indians and many of these examples have been vouched for by no less an authority than Grimm.

In the cosmogony of many peoples the sun and the moon are husband and wife, brother and sister, father and daughter and so on. When these luminaries are eclipsed it is because the husband and wife are quarreling or are having some domestic disputes. Among the Mbocobis of South America the moon is the man, and the sun, his wife. An Ottawa story describes the sun and the moon as brother and sister. Among the Egyptians Osiris and Isis were the sun and the moon, brother and sister, husband and wife; among the Incas, according to Lehmann-Nitsche, the sun was the man and the moon a woman, but no kinship existed between them. In England and in France the sun is the man (Eng. *the sun,* m., Fr. *le soleil*) and the moon is the woman (Eng. *the moon,* f., Fr. *la lune*); whereas in Germany the reverse is true (*der Mond,* m.,

die Sonne, f.). To these we may add Sp. *el sol,* m., *la luna,* f., It. *il sole,* m., *la luna,* f., Port. *o sol,* m., *a lua,* f. and many others too numerous to mention. The Arapaho believed that the moon was the brother and the sun the sister, and the same belief is found among the Menominee. In the extreme south the Onas regarded the sun and the moon as husband and wife, and the neighboring Yahgans think that the moon is the wife of the rainbow, but the sun is the elder brother of the moon and Venus. According to the mythology of the *Kojiki* the "moon-deity" is a male deity, but the common Japanese people who are unable to read the *Kojiki* address this deity as *O-Tsuki-San,* "Lady Moon." The Australian natives believe that the moon is a man and the sun a woman. The Greenlanders were of opinion that the sun was a man who was amorous at certain times, and hence they took measures to protect their women from the sun; and going south among the Hindus of Bengal we find that *"les jeunes filles non mariées craignent de sortir dans la lumière du soleil, particulièrement après la période de menstruation, de peur d'être fecondées par ses rayons."* Among the Eskimo the sun and the moon were originally sister and brother. The examples may be multiplied manyfold, but the above will show that similar beliefs are widely distributed over the face of the earth.

Talking of eclipses Brewer writes:

> Eclipses were considered by the ancient Greeks and Romans as bad omens. Nicias, the Athenian general, was so terrified by an eclipse of the moon, that he durst not defend himself from the Syracusans; in consequence of which his whole army was cut to pieces and he himself was put to death. . . . The Romans would never hold a public assembly during an eclipse. Some of their poets feign that an eclipse of the moon is because she is gone on a visit to Endymion . . . a very general opinion was and still is among the barbarians that the sun or moon has been devoured by some monster, and hence the custom of beating drums and brass kettles to scare the monster. . . . The Chinese, Lapps, Persians, and some others call the evil beast a dragon. The East Indians say it is a black griffin. . . . The notion of the ancient Mexicans was that eclipses were caused by sun and moon quarrels, in which one of the litigants is being beaten black and blue.

Similar beliefs and customs are known in the Old as well as in the New World. Below are given some of these beliefs as they are found in the different continents.

Europe

The Norsemen fancied that on the occasion of an eclipse the Mânagarmar or the moon-dog had already got a part of the shining orb between his jaws. The Esthonian explanation of these phenomena was very similar; the sun or the moon was being eaten. In Great Britain, the Irish and the Welsh run about beating kettles and pans during eclipses with the avowed intention of frightening the demon away. In the German provinces of Hessen and Westphalia, during an eclipse, poison is said to fall from heaven; hence cattle must be herded, wells kept covered and other necessary precautions are taken against any possible danger from this source. Identical beliefs are prevalent in Swabia. The Bavarian peasants too are firmly convinced that water is poisoned during an eclipse, and therefore they would not drink water at such a time. Thuringian peasants cover up wells and bring cattle home from pastures during eclipses of the sun and of the moon, and an eclipse is supposed to be specially dangerous if it happens to occur on a Wednesday. In certain parts of France they think that eclipses are caused by the luminary being destroyed. An eminent author relates how, during an eclipse, he heard a French peasant exclaim with deep anguish, *"Mon Dieu! Qu'elle est souffrante!"* and as an explanation pointed to the almost totally obscured moon.

Asia

In Arabia, according to Niebuhr, there was a belief that a huge fish pursued the planet that was eclipsed. In India, among the Hindus of the present day, eclipses are said to be caused by the demons Rāhu and Ketu. The former is a demon of a coal-black color who devours the sun, and causes a whole or a partial eclipse; he is said to be immortal, or rather his head is, because he had stolen into heaven and quaffed some of the nectar of immortality when Viṣṇu cut off his head. The latter is represented as being red in color and is the monster which devours the moon. As among the German peasants, the Hindus too believe that poison falls from the sky during eclipses. An eclipse whether of the sun or of the moon is regarded as auspicious; while if a solar eclipse occurs on a Sunday or a lunar eclipse on a Monday, the occasion is looked upon as especially auspicious. Some say that an eclipse is a time of ceremonial pollution when bathing becomes imperative.

Among the Garos, a Mongolian people of eastern Bengal, the "evil spirit Nawang is credited with being the cause of eclipses. He is said to swallow the sun and the moon. When the first shadow appears on the face of either, drums are beaten and horns blown to frighten the monster away." Among the Hindus of Southern India, if a child is born with a bodily defect, "it is attributed to the evil influence of two unlucky constellations which must have been in conjunction at the time of birth, or to some eclipse of the sun or moon that took place at that moment." The Chāmārs, the leather-working caste, believe that if an eclipse occurs during pregnancy, the woman must remain perfectly quiet, or the child will be deformed. The Todas abstain from food when they know that there is going to be an eclipse of the sun. But when there is a lunar eclipse they think that it is caused by a snake going to catch a hare which has taken refuge in the moon; the moon becomes dark in order to protect her protegé. During lunar eclipses some people fire guns and send up rockets and shout.

The Cambodians believe that eclipses are caused by monsters biting the luminaries.

A Mongolian has it that the gods wished to punish the maleficient Arakho for his misdeeds, but Arakho hid so cleverly that their limited omnipotence could not find him. The sun, when asked to turn spy, gave an evasive answer. The moon told the truth. Arakho was punished, and ever since he chases the sun and moon. When he nearly catches either of them, there is an eclipse, and the people try to drive him off by making a hideous uproar with musical and other instruments.

In China a solar eclipse forebodes an ominous future. At the time when an eclipse of the sun was foretold for the Chinese New Year's Day (A. D. 1850), Taokwang was so overcome by the dread of this combination of time that he ordered the New Year's Day to be postponed for twenty-four hours. They run about making a dreadful noise during eclipses so that the demon causing them may desist. In Sumatra, Marsden informs us, "during an eclipse they made a loud noise with sounding instruments to prevent one luminary from devouring another." Among the Semang eclipses are believed to be due to the attempt of a gigantic dragon or serpent to enfold or swallow the obscured luminary. In the case of the moon, it is the moon's own mother-in-law attempting to embrace her daughter-in-law, whereas in the case of the sun the attack is in deadly earnest. The Sakai too believe in a Rāhu. The Mantras believed the moon to be married to Moyang-Bertang, the man who lives in the moon and is visible as "moon-spots." The stars are her children. The sun and the moon agreed that if all the stars were left, there would be too much light for human beings; so it was decided not to have all

the children. The sun did as was agreed upon, but the moon did not. For this breech of agreement the sun naturally was incensed, and since that time periodically attacks the moon. Whenever the sun gets near enough to the moon to bite the orb, there is a lunar eclipse.

The Filipinos believe that eclipses are caused by a monster attempting to devour the moon; they too therefore resort to the ubiquitous practise of making a noise so that the demon may be frightened. When the sun and the moon were eclipsed, the Tahitians thought that they were copulating. Among the Polynesians some "imagined that in an eclipse, the sun and the moon were swallowed by the god which they had by neglect offended. Liberal presents were offered, which were supposed to induce the god to abate his anger, and eject the luminaries of day and night from his stomach."

In Australia an eclipse of either the sun or the moon is looked upon as a terrible calamity and as a sure portent of disease and death. The Arunta associate a solar eclipse with evil magic; their usual belief being that some evil spirit is trying to eat it up. They therefore, start throwing spears during eclipses, for that drives away the evil spirit which has come in front of the sun or the moon.

Africa

Among the ancient Babylonians and Assyrians eclipses had diverse significations. Thus it indicated an overthrow of kingdoms, flood, death, famine, miscarriage of women, revolt, rain, pestilence, war and so on. On the other hand, it also portended easy delivery of women, good crops and other equally good results. Among the Wa natives of East Africa eclipses of the moon are believed to be caused by that luminary fighting with the sun. The Wayao run hastily to fetch hoes and axes, and strike them against each other, looking up at the scene of strife and calling out, "Go asunder, go asunder, sun and moon, you have seized one another. Go asunder, go asunder now." They observe the same customs during solar eclipses. Some Berber people believe that an eclipse is caused by a fight between the sun and the moon.

North America

The Eskimo of the Lower Yukon think that "a subtle substance or unclean influence descends to the earth during an eclipse, and if any of it is caught in utensils of any kind it will produce sickness. As a result, immediately on the commencement of an eclipse, every woman turns bottomside up all her pots, wooden buckets and dishes." Among the Eskimo around Bering Strait a lunar eclipse is said to foretell an epidemic or war. The length of the duration of the eclipse is believed to indicate the severity of the visitation to follow. Some North American Indians thought that the moon was eclipsed "because she held her son in her arms, which prevented her brightness from being seen." The husband of the moon, they said, was the sun, and solar eclipses were caused "because he also sometimes takes the son which he has by the Moon, into his arms." The people of Nootka Sound attributed eclipses to the luminaries being pursued by a great cod fish. Among the Tlingit when the moon was darkened during an eclipse they blew out toward it to blow out sickness. The Tlascaltecs regarded the sun and the moon as husband and wife; eclipses, they averred, were mere domestic quarrels. During eclipses the Kwakiutl burn old stuff that gives off a bad smell. They think that eclipses are caused by the sun or the moon being swallowed, and the burning of the evil-smelling stuff is intended to liberate the sun. Among the Tillamook nobody was allowed to look upward during an eclipse. If a person had to leave the house, he must look down on the ground. It was believed that the killing of a person strong in magic caused

an eclipse, and every vessel in the house was turned over so that his blood should not drip into it.[1] Among the Coeur d'Alêne lunar eclipses are said to be caused by the moon covering the face or eyes. Skinner tells us that the Menominee regarded eclipses as presaging some dire calamity, so the warriors would fire at them to ward off the danger. And according to Le Jeune an almost identical custom was known among the Hurons. During eclipses the Chilcotin Indians walk in a circle, leaning on staves, apparently to assist the laboring orb. The Navaho Indians thought that the influenza epidemic of 1918 was caused by the solar eclipse which took place on June 8.

The Choctaw attributed solar eclipses to a black squirrel which tried to eat up the sun at different intervals; whenever the squirrel attempted to make such a meal, they made as much noise as possible by shrieking, beating on pans, firing guns, and so on. "But the din remained unabated until the sun again appeared in its usual splendor, and all nature again assumed its harmonious course." Those of Bayou Lacomb have a different explanation; they say that the sun walks every day, and hence he becomes dirty and smoked from the fire which is within him. It therefore behooves the sun to clean himself, after which he shines all the brighter. During the eclipse he is removing the accumulated dirt. They have a similar belief with regard to lunar eclipses. Of the Cherokee one of our older authorities, Adair, writes:

> The first lunar eclipse I saw after I had lived with the Indians was among the Cherokee, An. 1736, and during the continuance of it their conduct appeared very surprising to one who had not seen the like before. They all ran wild, this way and that way, like lunatics, firing their guns, whooping and hallooing, beating kettles, ringing horse bells and making the most horrid noises that human beings possibly could. This was the effect of their natural philosophy and done to assist the suffering moon.

Among the Creek Indians, when the sun or the moon was eclipsed, they thought that a great toad (*sàbăkti*), or pig, was about to swallow it; "and in order to help drive it away they discharged their guns at it and shot at it until they 'hit' it." According to other versions it was either a big dog or a frog which caused the eclipse.

The Assiniboin think that eclipses are caused by a hand, cloud or some other thing shadowing the moon. Eclipses portend great calamities, such as war, pestilence and famine. The Cocopas think that solar or lunar eclipses are caused by the great lizard (*kwachul*) devouring the luminaries. They thought that the dream of a lunar eclipse meant that enemies would soon kill them; the dream of a solar eclipse was a portent of success against the Yuma and was an incentive to campaign. "Moon on Cocopa side, sun on Yuma side." The Yumas think that a lunar eclipse is occasioned because a certain species of lizard, called *wasany,* is eating the moon. At eclipses the Juaneño shouted and made all possible sorts of noise to frighten away the monster which was thought to be devouring the sun or the moon. Kroeber says that it is probable that the custom was universal in California. Among the Shasta an eclipse of the moon is said to be due to the dog that follows the moon eating it up. People talk, therefore, to the dog, entreating it to desist, and howl and shout to frighten it away. Whenever there was a lunar eclipse the Alsea Indians shouted out loud, "Do you come out inside; the moon is now killed." They said that "the crow usually kills the moon, and also the eagle, and likewise (from) inside; do you come out (from) the chicken hawk and, moreover, the owl." During a solar eclipse which, they said, was caused by the sun being killed, "they upset all buckets and

[1] F. Boas, "Notes on the Tillamook," *University of California Publications in American Archeology and Ethnology,* xx, p. 9, 1923.

poured out the water because it was not desired that the water should become bloody when the sun was killed.'' If the Cahuilla ate during an eclipse, they were likely to eat a ''moon-spirit.'' Whoever died during an eclipse was thought to have eaten one of these ''moon-spirits.'' According to the Luiseño the ''eclipse of the moon is the physical manifestation of Ouiot's sickness when he counted the months expecting to die. When the eclipse clears off, Moyla, Ouiot, gets well again.''

Among the Southern Diegueño both young and old shoot during eclipses; they believe that eclipses cause sickness. During solar and lunar eclipses the San Luis Rey Indians shouted and made noises by clapping their hands. ''On being asked the reason, they have always answered . . . that they believe that an animal was trying to eat the sun or the moon, and that they did these extreme things in order to frighten him, thinking that if he ate them they would all perish.'' The Indians of San Juan Capistrano believed the same. Among the Serrano the first person who saw an eclipse of either the sun or the moon raised a shout which was taken up by everyone. Eclipses, they thought, were caused by the spirits of the dead, ''who were believed to be eating the dark portions on which the shadow fell.'' They would not touch any food while an eclipse was in progress; any one doing so would be assisting in the eating of the sun or the moon.

Central and South America

The ancient Mexicans thought that a solar eclipse was caused by a jaguar eating the luminary; and it was a common superstition among the Mexican women that children born during an eclipse would be turned into mice. The ancient Aztecs were careful that a pregnant woman should not see an eclipse, or her child would be metamorphosed into a rat or have some physical defect, such as a harelip. This belief persisted in Mexico as late as the nineteenth century. The danger, however, was nullified if the woman took the simple precaution of wearing an obsidian knife over her bare breast. In the state of Oaxaca it is still believed that pregnant women looking at a lunar eclipse will give birth to a harelipped baby; they think that eclipses of the moon are caused by the luminary being burned (''*porque la luna se está quemando*'').

The Yucatan Indians explained lunar eclipses by saying that either the moon was dying or that the orb was being bitten by a certain kind of ant called *xubab*. Talking of eclipses, Pedro Sanchez de Aguilar writes: ''*En los eclipses de Luna* [they] *usan por tradicion de sus passados hazer que sus perros aullen, o lloren, pellizcandoles el cuerpo, o las orejas, y dan golpes en las tablas, y vancos, y puertas.*''

The Caribs believed in a demon called Maboya, a hater of all light, who caused eclipses by devouring the sun or the moon. Maboya is said to have had the power of sending hurricanes, and is recognized as a sky god. In Cayenne eclipses are caused by monsters eating them; if the eclipse is total or of short duration they consider it a fatal thing for them. The Garifs regard an eclipse of the moon as being caused by Máfya, which no doubt is merely a dialectic form of Maboya.

During a solar eclipse the Arawaks rushed from their houses with loud shouts and yells, explaining that a fight was going on between the sun and the moon, and the shouting was to frighten and so part the combatants. The Chiquitos shoot arrows upward, and cry aloud to drive away dogs, who, they believe, hunt the moon through heaven; when the dogs overtake the luminary, the darkness of the orb is caused by the blood which runs from her wounds.

Among the Orinoco tribes lighted brands are carefully put away under-

ground during an eclipse of the moon; they thought that if the moon were to go out, all fires on the surface of the earth would also go out. At such times they seized their hoes and labored with exemplary vigor on their growing corn, saying that the moon was veiling herself in anger at their habitual laziness. The Sumu believe eclipses, both lunar and solar, are caused by a jaguar eating the luminary; hence they attempt to frighten the feline away by shooting arrows at it, making great fires and beating drums.

The Cuna Indians of Panama believe eclipses are caused by a demon—half dog, half woman—which starts eating the luminaries; they shoot at it with miniature arrows to make it desist. In Guarani belief eclipses are caused by "a jaguar and a great dog, which pursued the sun and the moon to devour them." The Uaupés Indians think that lunar eclipses are occasioned by the demon Yurupari killing the moon; hence they too frighten the demon by making a hideous noise. To give one more South American example we may mention the Kutašo of Brazil, of whom very little is known. They thought that every time the moon had a miscarriage, an eclipse resulted.

Conclusion

From the above survey, embracing as it does the whole of the habitable globe, we see that a large majority of peoples believed that eclipses were caused by the luminaries being threatened by some danger to their existence, and that this danger commonly took the form either of a demon or of a ferocious beast; the nature of the beast depended upon the climate and environments, and this beast has been variously described as a dog, a fish, a squirrel, a pig, a toad, a frog, an ant, a lizard and a jaguar. Considering, however, that means of communication were yet in their rudimentary stage among the primitive peoples, and considering the wide prevalence of the belief, it immediately becomes apparent that such beliefs could not have been borrowed, and that they must have had independent origins. Rudiments of science existed among all peoples no matter how low they might have been in the evolutionary scale.

The fact observed during eclipses was the dimness of the otherwise bright orb, and the natural solution which came to the mind of the primitive philosopher was that the dimness could have been caused by one of two reasons—either the orb was hiding, or that it was being destroyed. In the former case it was caused by shame. In the latter case, the only reasonable thing to suppose was that such destruction could take place only through the intermediary of a being mightier than the orb itself, and what could be more logical than to think that such a being was a demon or an immense beast?

Primitive man also noticed that eclipses were never permanent; hence the phenomena were explained by saying that the demon had to set the orb free, and they tried to hasten it by noises, shooting, and so on. The superstitions connected with eclipses all show that there is a general fear of being poisoned at such a time, and perhaps a typical one of these beliefs is that recorded of the Tillamook by Professor Boas.

Exact knowledge can only be gained by experience. Progress has necessarily been slow, and humanity has passed through stages the beginnings of which extend back to the hoary past—in magic. A study of any set of beliefs will show the same trend in reasoning through which man has passed on his road to civilization. There is much to be learned yet, and the longer we live, the better we realize how right Freud was when he said: "The man of prehistoric times lives on, unchanged, in our Unconscious."

SCIENCE SERVICE RADIO TALKS

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IS AMERICA ABOUT TO LOSE HER ELMS?

By Dr. STANLEY B. FRACKER

IN CHARGE OF THE DIVISION OF DOMESTIC PLANT QUARANTINE, U. S. DEPARTMENT OF AGRICULTURE

During the past generation, America has watched helplessly while the centuries-old chestnut forests of the East have been wiped out by an imported Asiatic disease. North of the Carolinas little now remains of the extensive stands of that valuable tree except thousands of gaunt, bare skeletons standing dead in great stretches of forest in the Appalachian range.

A similar forest tree disease known as the "Dutch elm disease" attacking elms was found last year strongly established in parts of New Jersey, New York and Connecticut. This disease was no stranger to us, for Americans have been watching with alarm the spread of this tree plague in Europe since it was found and described in 1919. No one knows what part of the world it originally came from or exactly when it reached Europe, but from the time it was discovered in Holland sixteen years ago it has swept east and south across Europe and west and north into the British Isles and has destroyed elms as it progressed. The rapidity with which it works and the suddenness with which the affected trees die, are quite without parallel among the diseases of forest and shade trees, with the exception of the already disastrous chestnut blight.

Beautiful shade trees in the most conspicuous places are among the favorite victims. The majestic rows of elms in the Versailles Park at Paris have been killed and taken out. Two thousand elms were destroyed in the Bremen district of Germany in 1930. Elms bordering the stately avenues of Bucharest, Hungary, and Vienna, Austria, found dead and dying, have been removed, and recent newspaper reports describe the destruction of the elms on the grounds of the Windsor Palace in England. In Rotterdam, Holland, in 1930, 17,000 elms were said to be killed by the disease, more than half of all the elms in the city. In the city of Baarn in Holland all the elm trees are reported to have been killed by 1930. Along the highways and canals and in the woodlands of the same countries, similar results have followed the introduction of this disease.

It was hoped that this tree plague could be kept from getting into America, and every effort was made to prevent its introduction. In spite of this attempt, the disease was found in New Jersey in June of last year and a few weeks later several cases were discovered in parts of New York and Connecticut. By the middle of last December over 800 trees were dead or dying of the Dutch elm disease in those three states, and diseased and infected trees are being found so rapidly this summer that the number found to be doomed from the disease is now about 6,800.

About the same time that the disease was discovered in New Jersey, the department learned that one way through which it was reaching this country was the importation of burl elm logs for manufacturing veneer for furniture. An examination of burl elm logs arriving from abroad last year showed that they had come from infected trees. As soon as that discovery was made the

further introduction of the disease in that manner was stopped by quarantine action. Plant quarantines were already preventing the importation of elm nursery stock.

The Dutch elm disease is caused by a fungus growing in the young sapwood. After getting into the tree this fungus grows rapidly and in the course of a few weeks or months the leaves wilt or turn yellow. Sometimes this wilting and yellowing is confined to a single branch and sometimes the entire tree seems to be affected at once and may die completely within two or three weeks after the first symptoms are seen.

So far as has been learned from experimental work, the spores or germs of this fungus do not seem to be carried by the wind or rain from one tree to another. It is thought they are introduced into healthy trees by small bark beetles. These beetles prefer weak, diseased or dying trees as places in which to lay and hatch their eggs, but unfortunately instead of feeding only on such weakened and sickly trees, the adult beetles get their food supply by feeding on the bark and twigs of the healthy elms. When they do this, it is believed they may introduce the fungus which causes Dutch elm disease and are thus able to spread the disease with such alarming rapidity.

There are other fungous diseases with similar symptoms attacking elms, but they are not as serious. The wilting and yellowing of the branches in the case of some of the other diseases very closely resemble the symptoms of the Dutch elm disease and some of them also show brown streaks in the sapwood, a striking characteristic of the Dutch elm disease. These fungi, however, do less damage, because they do not spread rapidly and the trees can frequently be saved by the removal of infected branches.

It is therefore a matter of the utmost importance to be able to determine positively whether an elm showing wilting and yellowing branches is infected with the disastrous plague known as the Dutch elm disease or whether it is only being attacked by one of the less harmful fungi. A special laboratory for this purpose has been set up by the department at Morristown, New Jersey. At this laboratory every specimen sent in is carefully examined and cultured and a definite diagnosis made. This is done not only for all the specimens sent in by the scouts in the infected areas of New Jersey, New York and Connecticut, but in the case of all specimens sent from other parts of the United States. Many such specimens from other parts of the country are being received, but none of them so far this year show the Dutch elm disease, except those from the known infected parts of the three states named.

Collecting specimens of diseased twigs is sometimes difficult. If the tree is small, samples may be taken from the ground by the aid of long-handled pruners. If the tree is large it must often be climbed, usually with the aid of ropes. Climbing irons such as are used by telephone linemen are injurious to the tree and can not be used on valuable trees. Several segments of branches about the size of a lead pencil or slightly larger taken from the affected part showing brown streaking in the sapwood usually constitute suitable material.

Once a tree is diseased there is no way of curing it. Last year some of the owners were anxious to save valuable elms when possible and in a number of cases only the wilting and yellowing branches were cut off in the hope of saving the trees. This has not proven effective, for the following year the rest of the tree usually succumbed.

The only practicable basis of safeguarding the healthy elms is a complete eradication of the disease by searching out and destroying the infected trees before the disease spreads to other trees. The obvious symptoms of the disease in a tree are evident during the growing season for six to ten weeks before the bark

beetles in the bark can mature and emerge to spread the disease. This makes it possible to locate and destroy the affected trees and thus prevent its dissemination by these beetles. It is evident, therefore, that if the disease is principally transmitted by these bark beetles, as is now strongly indicated, eradication is both practicable and feasible, providing the required work is done promptly and persistently.

The eradication of infected trees is often a difficult and costly problem. Street trees and trees near houses have to be removed in small sections and the sections let down by ropes. Prompt destruction of all the wood and bark of the diseased tree is required and this adds greatly to the cost of eradication. Elm wood is very heavy and must be sawed into short lengths for handling or else handled by the use of expensive and cumbersome machinery. In some cases even the latter can not be used to advantage because of the location of the tree against buildings, etc. The main purpose in diseased tree eradication is lost if the work is not completed before the bark beetles mature and emerge, thus spreading the disease to healthy trees. The green, wet and soggy wood is heavy to haul, and it can not be burned without the application of fuel oil, and constant tending of the fire is necessary in order to secure complete destruction. In the present eradication work the tree is sawed off near the ground line and the bark is removed from the stump. The stump is then heavily treated with creosote or other suitable fungicide.

Beginning in 1930, three years before the New Jersey outbreak was discovered, a number of infected trees were found in Ohio and last year one small tree was found in Maryland. Apparently the Dutch elm disease can be entirely eradicated in those states. This was a comparatively simple task, as it seems that the bark beetles which are concerned in the spread of the disease have not reached Ohio and Maryland. These beetles are found only in an area which extends from Philadelphia, northeast through southeastern New York and New Jersey to New England, as far as northeastern Massachusetts.

The present stage of the Dutch elm disease eradication work is that every elm in the infected area of some 3,000 square miles within approximately 25 miles of New York Harbor has been visited twice this summer and specimens of twigs have been taken in case there were any indications of wilting or yellowing foliage and brown streaks in the wood. In another belt almost 15 miles wide, completely around this central infected area, all the elms have been examined once. The employees of the U. S. Department of Agriculture on this project are now working in this outside zone, for it is exceedingly important to get out all these outlying trees farthest from the infection center before the disease can spread to greater distances. In the meantime the authorities of the three states concerned, together with the local groups, are directing all their resources to an attempt to cut down the trees in the infected area before the beetles can spread the disease from them. State and local funds unfortunately have, until the last week or two, been so limited that the state authorities had been unable to keep up with the new trees being found from day to day, and they have gotten far behind. It appears now that when fall comes some 1,500 to 2,000 diseased trees will still be standing, a menace from which the Dutch elm disease may again sweep outward next season. Past years' investigations have shown that in cases where diseased trees can not be destroyed promptly, the infection spreads to about six times as many trees the following year.

It is clear, therefore, that the battle is very far from being won and that if America is to keep out the infection and save her elms, the contest will have to be

fought next year even more vigorously than it has been this season. Neither is the fight entirely lost, for thousands of the diseased trees have been promptly destroyed, and probably hundreds of thousands of the little bark beetles which are believed to spread the disease have been prevented from carrying it to the other elms in the vicinity.

This country has proven in other similar campaigns that a new plant disease or a new insect arriving within our midst can be completely wiped out, if the effort is vigorous enough and the resources adequate for the job on hand. We believe that the Dutch elm disease can be eradicated from the United States and the elms of America protected from the disaster which has overtaken those of Europe if the diseased trees of the New York, New Jersey and Connecticut area can be found and destroyed fast enough and if the work can be continued until the last trace of this fungus is destroyed.

AUGUST 15, 1934

ALONG DARWIN'S TRAIL IN SOUTH AMERICA

By Dr. WILFRED H. OSGOOD

CURATOR OF ZOOLOGY, FIELD MUSEUM OF NATURAL HISTORY

A FEW years ago I spent some months with a party in search of animal life in southern South America—Chile, Argentine and Patagonia. This region is far beyond the Equator, in the south temperate zone, where the climate is much like our own, and there are no dangerous tropical diseases, no poisonous snakes, and no blood-thirsty lions or tigers. The animals that do live there are not widely known and the number of species is not large, but among them are some of great peculiarity and much interest.

The route followed took us down the west coast of South America to many of the localities visited by Charles Darwin on his famous "Naturalist's Voyage Around the World" and we had the pleasure of rediscovering, so to speak, many of the animals originally found by him a hundred years ago. Darwin was only 23 years old when he started on this great journey, and in the five years of continuous field work which followed, he laid the foundation for much of his later study. He not only proved himself to be a wonderfully accurate observer and a profound thinker, but also an energetic collector of natural history specimens. His collections in all branches of natural history subsequently furnished the basis for numerous scientific studies not only by himself but by various specialists, including many of the greatest zoologists, botanists and geologists of that time. Darwin's specimens, in this way, became standards of comparison and even now a great part of our knowledge of the natural history of southern South America is based on them. Therefore, the special student whose problems enter this field has been obliged to go to London to examine them. This was not always convenient and would not be necessary if duplicate specimens were in American museums. To get such duplicate specimens, therefore, was one of our objects.

During the voyage we made many short stops and saw much of interest, but most fascinating to naturalists were the great flocks of sea birds off the coast of Peru. These are the birds of the famous guano islands—cormorants, pelicans, gannets and a few other species—all birds of large size, strong flight and fish-eating habits. They are in such numbers that one scarcely believes his eyes and wonders how there can be fish enough in the sea to feed them. One

morning our ship was anchored in the midst of them and air and water were alive with birds in all directions. Long curving lines of cormorants stretched from one horizon to the other, an endless stream of flying birds forming a dark band just above the water and dividing the full expanse of the ocean. Nearer by, they lay in black rafts covering acres and acres on the water, while over them pretty white gulls wheeled and turned gracefully. Above our heads were flying birds in numbers only comparable to a swarm of gnats, but these were gannets, each as big as a small goose. They were engaged in fishing, falling like plummets all about us to hit the water with a chug and a splash and then rising to try again. Thousands were striking the water at once so it was covered with little spurts of spray as if receiving a rain of shot. Why a rising bird in such a melée never collided with a falling one was a mystery. It was a wonderful sight and probably could not be duplicated anywhere else in the world.

After landing in central Chile, which reminded us much of central California, we passed quickly southward to the islands of southern Chile, where we found heavy forests and a cool, moist climate. In this region northern and southern animals meet, and at one of our camps we were able to stand on shore with flocks of parrots screaming over our heads, and hummingbirds buzzing about them, while out on the water schools of penguins were playing. To a naturalist, this is very paradoxical, like finding Eskimos and Hottentots inhabiting the same island, for parrots and hummingbirds are usually tropical birds, while penguins are characteristic of the Antarctic region. The Chilean penguins belong to one of the small species known as Jackass penguins, a name applied because they have a call that suggests the braying of a mule. Their northward distribution on this coast is due to the cold Humboldt current.

One of the animals discovered by Darwin was a small, dark-colored fox from the island of Chiloe. In his book he relates that while walking on the shore one evening he saw a fox sitting on a point of rocks and so intently watching something in the distance that he was able to creep up quietly behind it and knock it on the head with his geological hammer. Since Darwin's time it had not been taken again, and I was anxious to secure a specimen, so I made inquiries about it as soon as I reached southern Chile. My first informant had lived some years on Chiloe Island and was well acquainted with its animals. Moreover, he had a Spanish edition of Darwin's book. When I mentioned the fox he threw up his hands exclaiming, and with true Latin politeness and delicacy stated that he had no desire to question the veracity of a great English scientist like Darwin, but that fox story was more than he could swallow. He had never heard of a fox on Chiloe Island, and even if he had, how could he be expected to believe that a man could walk up to one and kill it with a hammer! His arguments were good, but they only made me the more anxious to test the matter myself, so when I reached wilder parts of the island, I began immediately to look for fox tracks and soon found what I thought was at least one in the sand of a small beach. Knowing that foxes are often habitual beach combers and fond of fish, I set traps very carefully in the woods at each end of this beach and baited them with tempting fresh fish. The very next day I had a fine fox and two days later another, so Darwin's reputation was saved. It was saved at least so far as the existence of the fox is concerned, but that story of killing it with a hammer is another matter. Possibly it ought to be brought to the attention of the anti-Darwinians.

Perhaps the most attractive animal we found on Chiloe Island was the tiny deer which the natives call the pudu. It is the smallest of all the true deer. It stands about 17 inches high at the shoulders, weighs about 22 pounds when full grown, and has little spikes of horns just three inches long. The African dikdiks and the East Indian mouse deer are a little smaller, but they are not true deer. The pudu lives in the tangled depths of the forest where its narrow winding trails are too small to be followed by the hunter, so it is practically impossible to get one by shooting. When pursued by dogs, however, the little deer take to the water, where they can be overtaken by boats and lifted out alive. In this way we obtained several live ones and greatly enjoyed keeping them as pets in camp. The pudu has all the grace and attractiveness of the larger deer, with an added touch of daintiness which is given by its small size. Altogether it is one of the most attractive and lovable animals I've ever met. It is fairly well known to the Chileans, but has rarely been seen outside that country.

One of the more common and widely known animals of southern Chile is the coypu or nutria, an important fur-bearing animal. Its habits are amphibious, somewhat like those of the muskrat, but it is as large as a beaver and is sometimes called the South American beaver. In fact, if it were not for its long, round, ratlike tail, it would look very much like our northern beaver. Its fur when plucked and prepared also resembles beaver but is inferior to it. The fur is quite well known under the name nutria and is used extensively in this country. The females have an extraordinary adaptation for life in the water. The milk glands and nipples are not on the breast but on the back near the middle line, making it possible for the young to nurse while the mother is swimming about or floating on the water. In this remarkable adaptation it is unique among mammals. We had a live coypu in camp for some days and found the only thing it would eat was potato. The west coast of South America is the original home of the potato and there are various kinds of wild ones growing in Chile, so perhaps this is the explanation of the coypu's taste.

There are no more snakes in southern Chile than in Ireland, but frogs and toads are numerous. Among them is one with peculiar breeding habits. This little frog was also discovered by Darwin and is now called Darwin's frog. It is a tiny little chap scarcely more than an inch long, bright green in color, and it has a sharp little proboscis on its nose. In this species the eggs, after being laid by the female, are picked up by the male and held in his mouth or in a pouch in his throat. He carries them here until the fully formed young are hatched, for in this frog there is no tadpole stage. As the embryo frogs develop, the pouch extends backward between the skin and muscle of the abdomen until it occupies the whole abdominal area, giving their father, who acts as sort of brooder, a very bloated appearance. Meanwhile, the female parent, the mother, has no further responsibility after having produced the eggs.

From the wet forests of the Chilean coast, our party crossed the mountains to the eastward and came out on the open grassy pampas of Patagonia, much like our western prairies. Here we found ourselves in an entirely different world of animal life. Although it may seem strange, animals are more numerous on the pampa than in the forest. Most conspicuous are the water birds—ducks, geese, swans, snipe, plover, divers and waders, which occur in flocks and can be seen for long distances. There are many small ponds scattered over the pampa and, especially near the base of the mountains, numerous springs of

clear water surrounded by great areas of open swamp which furnish ideal feeding and nesting conditions for these birds. Geese, which are mostly white in color, are found by thousands, tens of thousands and even hundreds of thousands. As they sit close together on the level plain they look like great patches of snow. Much more beautiful than the geese are the stately black-necked swans, one of the finest of all birds. They are not found everywhere in the pampa, but are common enough so that in a few weeks' time we saw a total of several hundred. Domesticated swans in city parks are always pleasing, but wild swans in a wild setting, seen by stealth and usually from concealment, never fail to fascinate as one of the most charming sights in nature.

A bird which gave an especial thrill when first sighted was the southern or Andean flamingo. Under warm skies with the lazy serenity of tropical seas and palm-bordered islands, flamingoes usually provide an unforgetable feast for the eye, whether to ornithologist or layman. In bleak Patagonia they were no less entrancing. Like the penguins on the coast, they seemed curiously out of place, and this impression was heightened by encountering them late in the season when the chilly blasts of approaching winter were beginning their famous "roaring." Once a flock of nearly a hundred was seen under especially captivating circumstances. Our small party was returning from a hard day's ride, tired, chilled and buffeted by fierce winds. Leaving the pampa we began threading about in adjoining foothills just as a squall broke with a heavy fall of snow. As we topped a small rise, a circular basin lay just below us containing a shallow lake where a flock of flamingoes was enjoying protection from the wind. We stood for a moment transfixed while the pink-bodied, stately birds hesitated. Then they rose and wheeled about us with the brown hills as a background and the great white flakes of snow pelting against their soft-colored forms. A sudden burst of light from the west fell on the scene and the birds disappeared in the flying snow leaving us with a lifetime memory.

Besides the water-birds, the most interesting bird of the pampa is the rhea or South American ostrich. This is quite common and as many as 40 or 50 may be seen in a single day's ride. It is said that the story of the ostrich's hiding its head in the sand is not strictly true, but our experience corroborates the idea that it is a very foolish bird. On our first ostrich hunt, we sighted one and took after it on horseback. It ran until it came to a barbed wire fence, then turned and followed the fence for about a half mile until it reached a small round corral which had been made for temporary use by sheep herders. It ran directly into the corral and then circled around inside until we rode up and easily knocked it on the head with the butt of a whip.

The principal large mammal of the pampa is the guanaco, sometimes called American camel, because it is in fact related to the camels. It is the wild stock from which the domesticated llamas and alpacas of Peru and Bolivia were derived. In Patagonia, it is still to be seen in herds numbering several hundred, much as antelope used to be on our western plains. Hunting it was rather exciting and not altogether easy. It is done mainly on horseback, and after sighting the animals, one may have to ride madly over rough country to get within range or to head them off. Although there is some demand for their hair and hides, they have not yet been hunted to the verge of extinction. Since Patagonia is unlikely to become very populous, there is hope that they may maintain themselves there for years to come.

At least one other interesting animal should be mentioned. This is the chinchilla of the high Andes of northern Chile. It was fairly common only a few years ago, but the demand for its beautiful fur has been so great that it is now very rare, and if it were not for the fact that it lives in the highest and most remote parts of the mountains, probably it would be quite extinct. It is a rodent not closely related to any northern animals, although it is about the size and somewhat the appearance of a small rabbit, with a long bushy tail something like that of some of our mountain pack rats or wood rats. It lives in broken rock at elevations of 14,000 feet and higher. Such places, in the winter season when the fur is most valuable, are almost inaccessible and the chinchilla hunters endure very great hardships. Our experience with it was confined to observation of captive specimens in the hands of natives who are contributing to an effort now being made to introduce it into the mountains of California and elsewhere in the United States. As a wild animal it seems practically doomed, but semi-domestication may save it from total disappearance.

SCIENCE AND THE RECOVERY PROGRAM

By Dr. A. M. MacMAHON

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Looking back through six thousand years of human history, we are always impressed with almost countless trends and changes in the affairs of men. At least one trend, however, has clearly preserved its course into modern times. Much older than written records, it started with the primitive beginnings from which the home evolved. Later, from motives of protection or aggression, in one line of endeavor or another, families grouped themselves into villages and tribes. Tribes formed states, and, in time, states became consolidated into nations. Our own generation has witnessed the birth of that struggling babe, the League of Nations. Whatever our views regarding the details, we must recognize that, in the long trail that has been beaten out between savagery and civilization, the most significant trend has been a marked improvement in man's ability to get along with his fellows. Underlying this movement has been an ever-increasing realization of the existence of great general truths, known and unknown, which apply to us all, individually and collectively, and a long-tested belief in the social effectiveness of the spirit of fair play. I would relate these fundamentals to the origin and growth of scientific activities throughout the world, and, in so doing, review the part which men of science play in raising the economic status of mankind.

Nature has taught man his regard for truths, and his ideals of fair play, largely of social origin, have shown him how to develop them. Each day the sun rises, each month the moon appears in her familiar phases, each year the seasons follow in regular succession, each time an apple grows ripe and falls to the ground, brings anew the lesson of an orderly universe without which no knowledge of future value would be possible. Examples of the integrity of nature are legion, but their observation alone has not built the connected body of knowledge which we call science. It is the fair-minded comparison of observational data from all sources which leads to the discovery of the general truths so essential to their systematic

organization. Therein lies the power of science in the service of man, since it provides an expanding and already surprisingly unified view of the circumstances under which he lives. For science, like art, belongs to the whole world; before them vanish, as never before, the barriers of nationality.

The comparatively recent recognition of the scientific method of extending the boundaries of human knowledge and the rapidity with which its conscious application has met with success are of considerable importance to the understanding of a world-wide economic depression and to the formulation of remedies which may help us to avoid a recurrence. Some intuitive appreciation of the possibilities of science is probably as old as the race, but its effective organization is relatively new. For example, the ancients knew that the moon receives its light from the sun. Again, the eclipses of the sun were observed with such care by the Chaldean priests that their data have proved quite valuable to the astronomers of to-day. Centuries before the birth of Christ, the Egyptians fixed the length of the solar year to one part in ten thousand. Also, Eratosthenes, a Grecian scholar of the third century, B.C., surveyed the distance between two cities located upon the same meridian and calculated a polar diameter for the earth equivalent to 7,850 miles, within fifty miles of the value now accepted. As a rule, however, the ancient workers were isolated and but few of their meager records have been preserved. Modern science made its strong beginning only three or four centuries ago when the spread of the art of printing made it possible to give a wide circulation to detailed information. The past hundred years have brought the most rapid scientific progress in history. Where, in any one generation, the ancients numbered their scientific workers by the dozens, we now number them by the tens of thousands. National and international groups have sprung up for the comparison of data, the exchange and criticism of coordinating ideas and the planning of future researches. Appreciation of the value of the experiment under controlled conditions has grown by leaps and bounds. Patient measurement and constant checking of data by numerous investigators have piled fact upon fact. Out of these accepted results have arisen the general truths whose vigorous influence upon the invention and development of new devices has frequently culminated in the creation of huge new industries. It is only the speed with which these things have been accomplished that has temporarily confused our powers of social and economic readjustment.

During the last century of the sixty for which major human events have been recorded, practically every activity of man essential to his physical well-being has been enlarged and markedly improved. The grain farmer, the dairyman, the truck gardener, the livestock grower, the wool producer and the cotton planter provide, or can provide, an abundance of the commodities fundamental to life. The geologist has revealed great stores of raw materials, hitherto unknown, in the earth's crust. The mining engineer secures and extracts their valuable constituents for use as fuels and materials of construction; the chemist is able, in thousands of cases, to separate them into their elements and recombine them into alloys and synthetics to suit particular needs, never before adequately satisfied. Steam and electric trains, automobiles, airplanes, huge seagoing liners and freighters give means of transportation which have made the world a neighborhood. Travel and exchange of goods go on at a rate never dreamed of in olden times. Not long were we content with the post and the electromagnetic telegraph. We must

talk across continents and over oceans. Communication, that great leveler of man's difficulties with his remote companions, has been made swift and easy. Over the radio the Chief Executive of our government frequently reaches millions of people in a single speech. In the manufacturing industries, processes and machines have been developed not only for the economical, large-scale production of the necessities of life but also for making generally available many of the old-time luxuries at greatly reduced cost. Compare the conveniences of the average modern home with those of the Middle Ages and you have a proof. If the medical profession and the sanitary engineer have not completely eliminated plagues and pestilences from the face of the globe, they have, at least, made it a far safer place to live on and have added considerably to the comfort and average span of life.

Thus, in addition to its rôle as a great emancipator of labor, science extends human activities and enriches human existence. By pushing forward man's economic frontier—meaning, the conditions affecting the production, distribution and consumption of the world's goods—the increasing applications of science multiply, correspondingly, the number of interesting jobs all the way along the line. Look at the statistics! The twentieth century, at its worst, sees more men and women employed in gainful, healthful occupations than any previous period in man's career. As a people, we have only to master the social problems connected with the uses of the machine to obtain a freedom never widely realized in any previous epoch of the history of the race.

A freedom for what! Everywhere, the pertinent question to be asked of any new program is, principally, not how we are to profit in a material sense but whither its following may lead us. No one can predict exactly, but we can all try; we can have an objective. Human values are almost as varied as the individuals born to live, but conserved in our democratic ideals are tremendous racial experiences, which are as much the tests of social truths as the achievements of experimental science are tests of the truths of nature. Our democratic ideals would assure every newcomer of his rights, among his fellows, to an opportunity for a full development of his talents, with a variety of social rewards, according to his merits. Free competition seems to be the best way for taking care of equality of opportunity; even the genius must acknowledge his debt to the social stimulus. We, therefore, subscribe to a form of government, known as a democracy, based upon the similarities and not the differences between men. If we so will, increased leisure time may lead to a more complete realization of these ideals for all of us, with large social and individual economies; and, if anyone doubts that the race has already traveled a long way in their pursuit, let him compare the motives underlying the economic statecraft of a Hoover, a Roosevelt or a MacDonald with those apparent in the dynastic intrigues of a Henry VIII or with the highly accentuated personal ambitions of a Napoleon. Like science, a substantial and enduring government is founded upon principles of truth and fair play. The solidarity and strength of a people depend upon how thoroughly they understand and apply these principles, always basic to their present status as well as to their spiritual and material growth.

In the advancement of democratic ideals, it is believed that a wider and more intimate understanding of scientific and industrial movements is required in the future for the proper coordination of national and international activities. All of us must become more familiar with their elementary and basic features, at least, if our efforts are to contribute

toward rather than retard the general progress. Science has provided mankind with amazing new tools and a powerful method for solving his problems. Let us learn to use them, intelligently.

Educationally, the solution is simpler than it seems at first sight. Show the public the unvarnished facts of scientific and industrial influences. Provide the opportunity for cultivating realism. Collect the masterpieces of science and engineering and operate them in an intelligible and dramatic manner. Demonstrate the principles upon which they are based. Effectively, take the people into the laboratories and factories of the past and present, supplying the human element with guides and attendants competent to aid and instruct. Let every interested person browse freely among the exhibits, many of which he may operate for himself, and absorb first-hand the story of the cotton gin, spinning wheel and loom, the forge and the steel mill, the steam engine and the electric motor, the telegraph and the telephone, the horse, tractor and automobile, the sailboat and the liner, the hut and the skyscraper. Present the fundamental phenomena of mechanics and electricity, heat, sound and optics. Show why scientists believe in atoms, the building blocks for all substances, useful and unused, animal, vegetable or mineral. Teach the strength of the picture of the electrical structure of matter; this coordinated view of the material world not only has affected numerous long-established industries but also has given rise to many new ones. Give the public a chance to understand, clearly, by personal contact, what is going on, a privilege hitherto enjoyed only by the specialist in a rather piecemeal fashion. Natural leaders will then arise to take care of the problems which beset us. Instill in the public mind the lesson that progress has come and can only come through a willingness to make intelligent changes, and enthusiastic support will not be lacking to them.

Supplementing the work of colleges, universities and public schools, institutions designed to accomplish these purposes with full-sized operating exhibits are arising all over the world. Germany, France and England have had them for many years. In the United States, the Smithsonian Institution of Washington, D. C., the Franklin Institute of Philadelphia, the New York Museum of Science and Industry, the Ford Museum of Dearborn, Michigan, and the Museum of Science and Industry of Chicago are examples. Japan and China are making plans for similar enterprises in public education.

We may conclude with a modern version of some of the thoughts of Louis Pasteur. "If the conquests useful for humanity touch your heart, if you are inspired by the astonishing results of photography, aeronautics, radio, anesthesia, the germ theory of disease and other wonderful discoveries, if you are proud of the part your country may claim in spreading these marvelous things, take an interest in those sacred places, the laboratories of science. Demand that they be multiplied and improved. These are the temples of the future, of health, prosperity and well-being. In them humanity grows, fortifies itself and becomes better. There we may learn to read in the works of nature the story of progress and to envisage such universal harmony as it may be our lot to achieve."

THE "LIE-DETECTOR"

By FRED E. INBAU
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LONG before psychologists ever attempted to develop a scientific technique for detecting deception, persons of average intelligence must have observed the fact that conscious lying ordinarily produces certain emotional disturbances—such as blushing, squinting of eyes, squirming, peculiar monotone of the voice, throat pulsation, cold sweat and a host of other manifestations. In China there existed a practise of requesting an accused to chew rice and then spit it out for examination—and if the rice were dry the subject was considered guilty, because his fear of guilt was supposed to inhibit the secretion of saliva. In India the movement of a suspect's big toe was supposed to be an indication of deception. The courts of law in our own country sanction the consideration by a jury of many bodily activities frequently displayed by a lying witness or a guilty defendant. For instance, a judge may, with all propriety, instruct a jury that in determining the credibility which should be accorded the testimony of a defendant in a criminal case they may take into consideration his demeanor and conduct both upon the witness stand and during the trial. Moreover, the conduct, general behavior and words of a person charged with crime, about the time of its commission or its discovery or upon his arrest for or upon his accusation of it, are admissible as evidence against him. It is apparent, therefore, that the notion of detecting deception by utilizing certain psychophysiological principles is not entirely new.

In their efforts to develop an accurate and reliable "lie-detector," scientific investigators have obtained the most encouraging and satisfactory results from experimentation regarding the symptomatic changes in respiration and blood-pressure. Many years of experimentation, principally by three men in this country, W. M. Marston, John A. Larson and Leonarde Keeler, has resulted in the development of a very useful technique for detecting deception.

The instrument used for this purpose, the Keeler Polygraph (Figs. 1 and 2), consists of three units—one for recording respiratory changes; another for continuously recording the pulse wave and blood-pressure; and a third for recording a duplicate blood-pressure-pulse curve or for recording muscular reflexes of the arm or leg. (Ordinarily only the first two units are used; the third serving merely as an accessory.)

For obtaining these bodily reactions, a rubber tube (pneumograph) is placed around the chest, and a blood-pressure cuff, of the type ordinarily used by physicians, is fastened about the upper arm and then inflated to a pressure about midway between the systolic and diastolic blood pressures. Hollow rubber tubes of approximately one quarter of an inch in diameter lead from both the pneumograph and the cuff into metal tambours, to which are attached two styluses. At the tip of each stylus is a small cup which is kept filled with ink and which feeds the pens as they fluctuate with each pulse beat or respiratory movement. The recordations are made upon slowly moving graph paper driven by a small synchronous electric motor.

An instrument of this type should be distinguished from the numerous

FIG. 1. THE POLYGRAPH IN OPERATION

other so-called "lie-detectors" frequently found in the psychology departments of many universities. Usually such experimental devices consist of a galvanometer and Wheatstone bridge—an instrument for observing the psycho-galvanic reflex, that is, the changes in skin resistance when an imperceptible current of electricity is flowing through the subject's body during the period of questioning. The galvanometric change in the body serves as an extremely sensitive criterion for emotionality, but can not by itself be depended upon as a means for the detection of deception. Used, however, in conjunction with the other two reactions (blood-pressure and respiration), it may be of considerable assistance. The new Polygraph will contain this unit in addition to the others previously mentioned.

Ordinary physiological abnormalities, such as high blood pressure, irregular pulse, etc., or emotional instability caused by fear, anger or other disturbing factors, do not interfere with the deception test, because these irregularities are ascertained in the "control" part of the record. In other words, that part of the record made by the subject while being asked the few customary irrelevant question (*e.g.*, "Have you had breakfast this morning?"—requiring an answer of "yes" or "no," without any explanatory remarks) will indicate the physiological and psychological peculiarities of the particular individual. Significance is attached only to the deviations from the "norm" at the points where the subject is being interrogated as to his participation in the crime under investigation. A study of the records pictured herein will illustrate the principle more clearly than words can describe.

Within the past three years at the Scientific Crime Detection Laboratory of Northwestern University School of Law, Professor Keeler and other staff members have examined approximately 3,500 individuals involved in all sorts of crimes, ranging from petty theft to murder, and the results have been very encouraging.

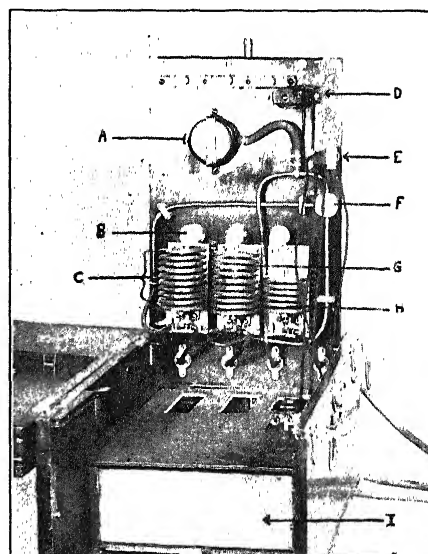


FIG. 2. INTERIOR VIEW OF POLYGRAPH
A, SPHYGMOMANOMETER; B, PIVOT SHAFT ASSEMBLED; C, TAMBOUR, BLOOD PRESSURE UNIT NO. 1; D, SIGNAL MAGNET; E, TOGGLE SWITCH; F, SELECTOR VALVE; G, TAMBOUR, BLOOD PRESSURE UNIT NO. 2; H, TAMBOUR, RESPIRATORY UNIT; I, DRAWER COMPARTMENT FOR ACCESSORIES; J, SPACE OCCUPIED BY KYMOGRAPH UNIT (MOTOR, GEAR TRAIN, PAPER ROLL SPROCKET).

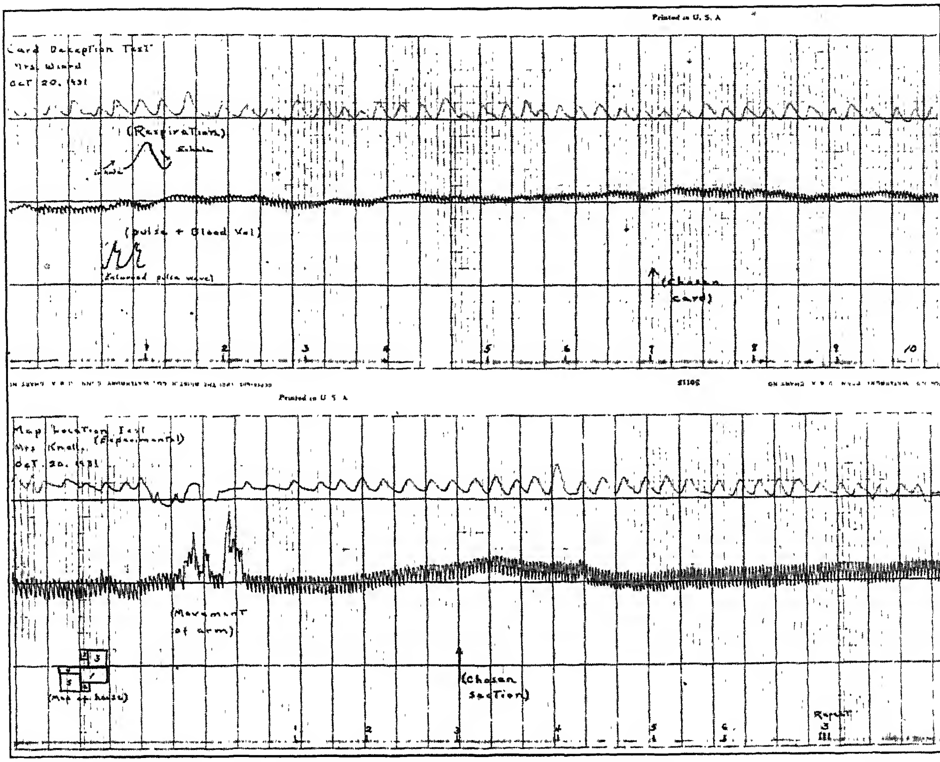
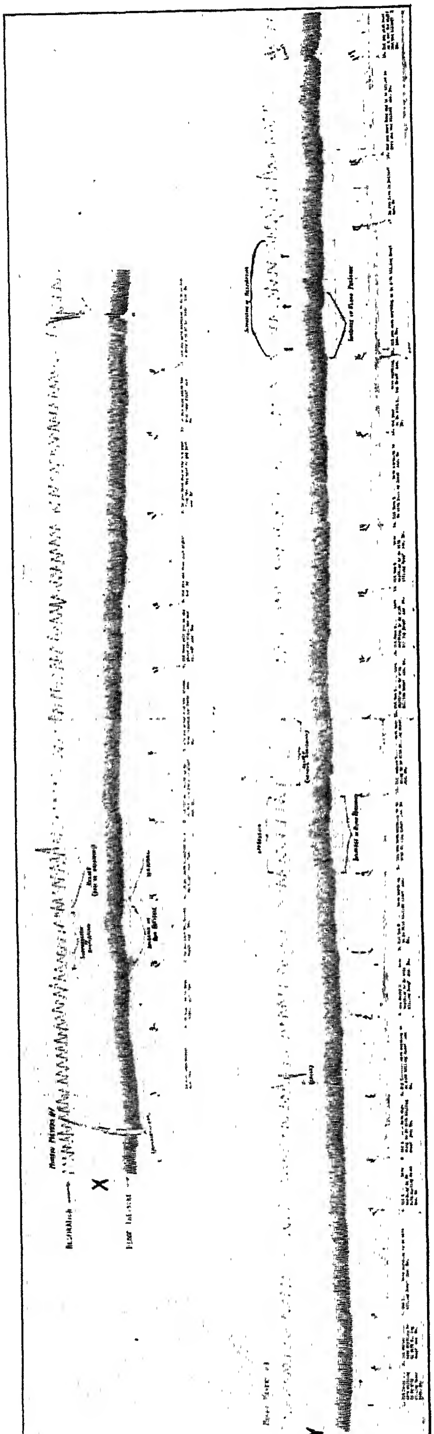


FIG. 3. EXPERIMENTAL RECORDS

THE INSTRUMENT WORKS WITH APPROXIMATELY EIGHTY PER CENT. ACCURACY IN CASES WHERE INDIVIDUALS "LIE MERELY FOR THE FUN OF IT." THE ARROW ON EACH RECORD INDICATES THE PEAK OF TENSION IN THE SUBJECT'S BLOOD PRESSURE CURVE—THE POINT AT WHICH THE LIE WAS TOLD. IN EXPERIMENTAL CASES OF THIS TYPE THE RESPONSE IS INDICATED MORE OFTEN IN THE BLOOD PRESSURE CURVE THAN IN THE RESPIRATORY CURVE.

Although no claim is made as to the infallibility of the Polygraph deception test technique, statistical data definitely establish the fact that it is an extremely valuable method for determining guilt or innocence. In experimental cases (see records in Fig. 3), the outcome of which is of no import to the individual being tested, there is an accuracy of approximately 85 per cent. And frequently in those instances where no significant response is given, if a monetary wager is made with the subject that his lie can be detected (*i.e.*, chosen card, chosen number, etc.), the existence of this "stake" will cause a significant response to be recorded on the instrument. In criminal cases, statistical data are difficult to obtain. For instance, in cases where a suspect's Polygraph record contains significant responses indicating his guilt, but no substantiating or discrediting evidence is ever obtained by the police, and no admissions are made by the suspect himself, such a record will remain "an unknown quantity" as far as statistical data are concerned. However, in numerous criminal cases, full confessions have been obtained in approximately 75 per cent. of those in which the record indicated deception regarding the pertinent questions propounded of the suspect.

Several months ago, the prosecuting



attorney of Rock Island, Illinois, solicited the services of the laboratory in an effort to solve the murder of a young girl. There were about fourteen people who "might have" committed the crime. All were subjected to the "lie-detector" tests. One gave what was interpreted as being a guilty record. The authorities were so informed. But before any action was taken, this particular individual fled town. He finally returned and made a partial confession. Other evidence conclusively established his guilt, and he is now serving a ninety-year sentence for the offence. The Polygraph records of this case (Figs. 4 and 5) furnish a neat comparison between "guilty" and "innocent" records.

During the past three years approximately 2,000 bank employees in 52 Chicago banks have been examined on this instrument in an effort to detect the embezzlers of various sums of money. From 10 to 25 per cent. of the entire personnel of many banks so examined were found to be lying regarding the thefts of money belonging to the institutions. And practically all such Polygraph records have been substantiated by admissions from the employees themselves.

In one instance a bank desired to detect the embezzler of a sum of $5,000. Tests were run upon all 56 employees,

FIG. 4. A POLYGRAPH RECORD

IN RECORD X NOTICE THE INCREASE IN BLOOD PRESSURE AND THE CORRESPONDING SUPPRESSION IN RESPIRATION AT THE TIME THE ANSWER WAS GIVEN TO QUESTION 3—"DO YOU KNOW WHO KILLED ROSE?" COMPARE THIS RESPONSE TO THE ONE FOUND AT THE TIME OF ANSWER TO QUESTION 4—"DID YOU HAVE BREAKFAST THIS MORNING?" NOTICE THE RELIEF IN RESPIRATION—HEAVIER BREATHING, AND THE NORMAL BLOOD PRESSURE CURVE. IN RECORD Y SIMILAR RESPONSES ARE TO BE FOUND AT THE TIME ANSWERS WERE GIVEN TO PERTINENT QUESTIONS.

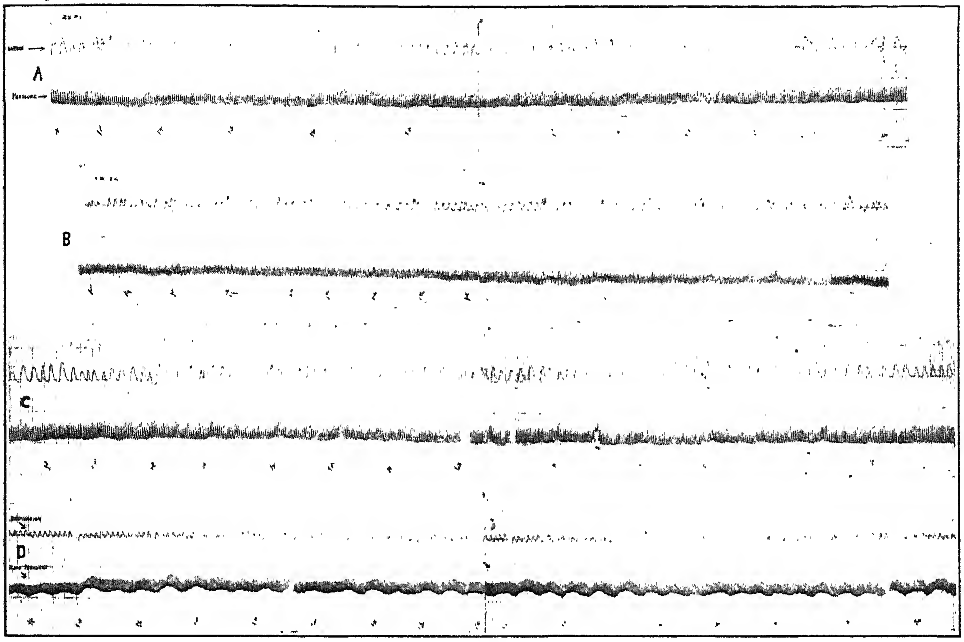


FIG. 5. "INNOCENT" RECORDS

A, B, C, D ARE RECORDS OF INNOCENT SUSPECTS. D ILLUSTRATES THE EFFECT OF MERE NERVOUSNESS IN AN INNOCENT SUSPECT. HIS RESPONSES TO PERTINENT QUESTIONS ARE NO MORE SIGNIFICANT THAN THOSE TO IRRELEVANT QUESTIONS.

but, instead of finding one liar in the group, twelve were discovered. Of the twelve, nine confessed to embezzlements hitherto unknown to the bank officials.

Several Chicago banking institutions will not employ an applicant for a position unless he is tested on the "lie-detector." Fig. 6 is a sample of the type of record frequently obtained in such examinations. In that particular case, after the subject admitted everything he had taken from previous employers, his second Polygraph record was free from significant responses. (Both records were run within ten minutes time of each other.) In such instances as this one the individual is usually recommended as a "good risk." Past experience has indicated that an individual of this type, who readily admits his previous mistakes and irregularities, is not likely to repeat his dishonest practices.

It must be remembered that the successful use of any such device depends largely upon the skill of the operator in selecting the questions propounded and in correlating the emotional responses. This is something an untrained individual can not do. And for that reason Professor Keeler has attempted to limit the distribution of the instrument to individuals who have demonstrated their ability as operators and who are either reputable members of the medical profession, or officially connected with educational institutions or recognized law-enforcing agencies. An instrument of this nature in the hands of an unscrupulous individual is an extremely dangerous thing.

One might naturally inquire at this point as to the admissibility of the "lie-detector" as evidence in a court of law. "If the instrument is as reliable as you

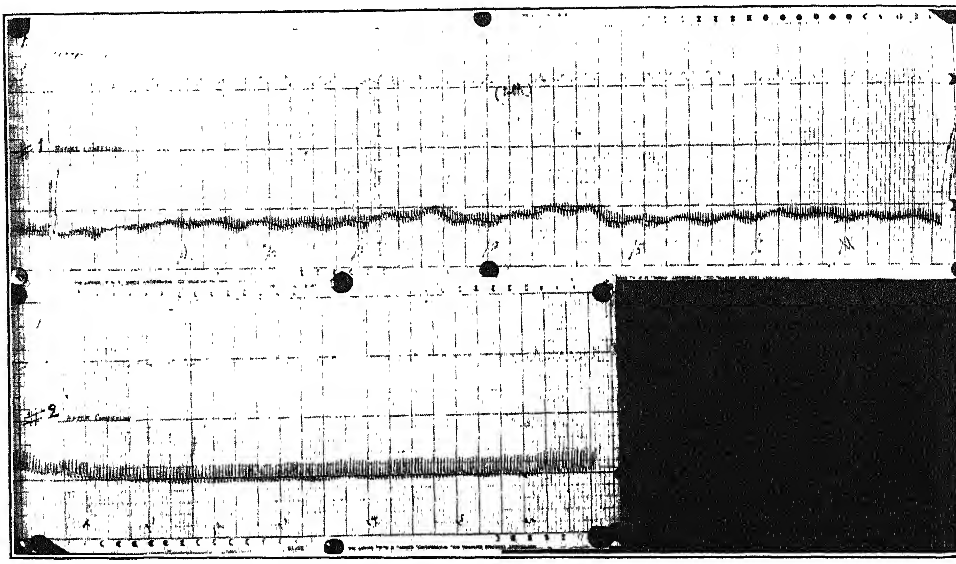


FIG. 6. TESTING APPLICANTS FOR POSITIONS

AT THE PLACE MARKED X THE SUBJECT WAS TOLD TO ANSWER ALL QUESTIONS BY EITHER "YES" OR "NO" AND TO RESERVE ANY EXPLANATIONS UNTIL AFTER THE COMPLETION OF THE TEST: (1) DO YOU LIVE IN CHICAGO? ANS. YES. (2) HAVE YOU HAD BREAKFAST THIS MORNING? YES. (3) HAVE YOU EVER TAKEN MONEY FROM A PREVIOUS EMPLOYER? NO. (4) DID YOU EVER TAKE ANY MONEY WHILE EMPLOYED AT THE ——— CO.? NO. (5) DID YOU HAVE LUNCHEON TO-DAY? YES. (6) DID YOU EVER TAKE ANY MONEY FROM A PREVIOUS EMPLOYER? NO. AFTER THE SUBJECT WAS INFORMED AS TO THE IRREGULARITIES IN HIS POLYGRAPH RECORD HE READILY ADMITTED HAVING TAKEN APPROXIMATELY $75, IN CASH AND IN MERCHANDISE. HE WAS THEN REEXAMINED. THE FOLLOWING QUESTIONS WERE ASKED: (1) IS YOUR FIRST NAME RICHARD? YES. (2) DO YOU LIVE IN CHICAGO? YES. (3) HAVE YOU TOLD US OF EVERYTHING YOU HAVE TAKEN FROM PREVIOUS EMPLOYERS? YES. (4) DID YOU TAKE ANY OTHER CASH FROM THE ——— CO? NO. (5) IF YOU GET THE POSITION WITH THE ——— COMPANY, DO YOU THINK YOU COULD BE ABSOLUTELY HONEST? YES, YOU BET I COULD. THE SUBJECT WAS RECOMMENDED FOR THE POSITION.

say it is, why has it not received judicial recognition?" That question may be answered by the suggestion that it must go through the stages of all things new. Consider, for example, the history of fingerprint evidence. The practical application of fingerprinting over a score of years was required before an appellate court approved of its use in a criminal case.

Eventually, "lie-detector" testimony will probably be admitted as evidence. At the present time, however, there are two appellate court decisions in which the use of any such instrument was disapproved. One is a federal case of 1923 —*Frye* v. *United States*—and the other a recent Wisconsin decision—*State* v. *Bohner*. Neither the Scientific Crime Detection Laboratory nor any one representing this institution participated in either case, although there is some language used in the Wisconsin case which carries that impression.

The reason for the present inadmissibility of "lie-detector" evidence is very well expressed in the opinion of the Federal court in the Frye case:

Just when a scientific principle or discovery crosses the line between the experimental and

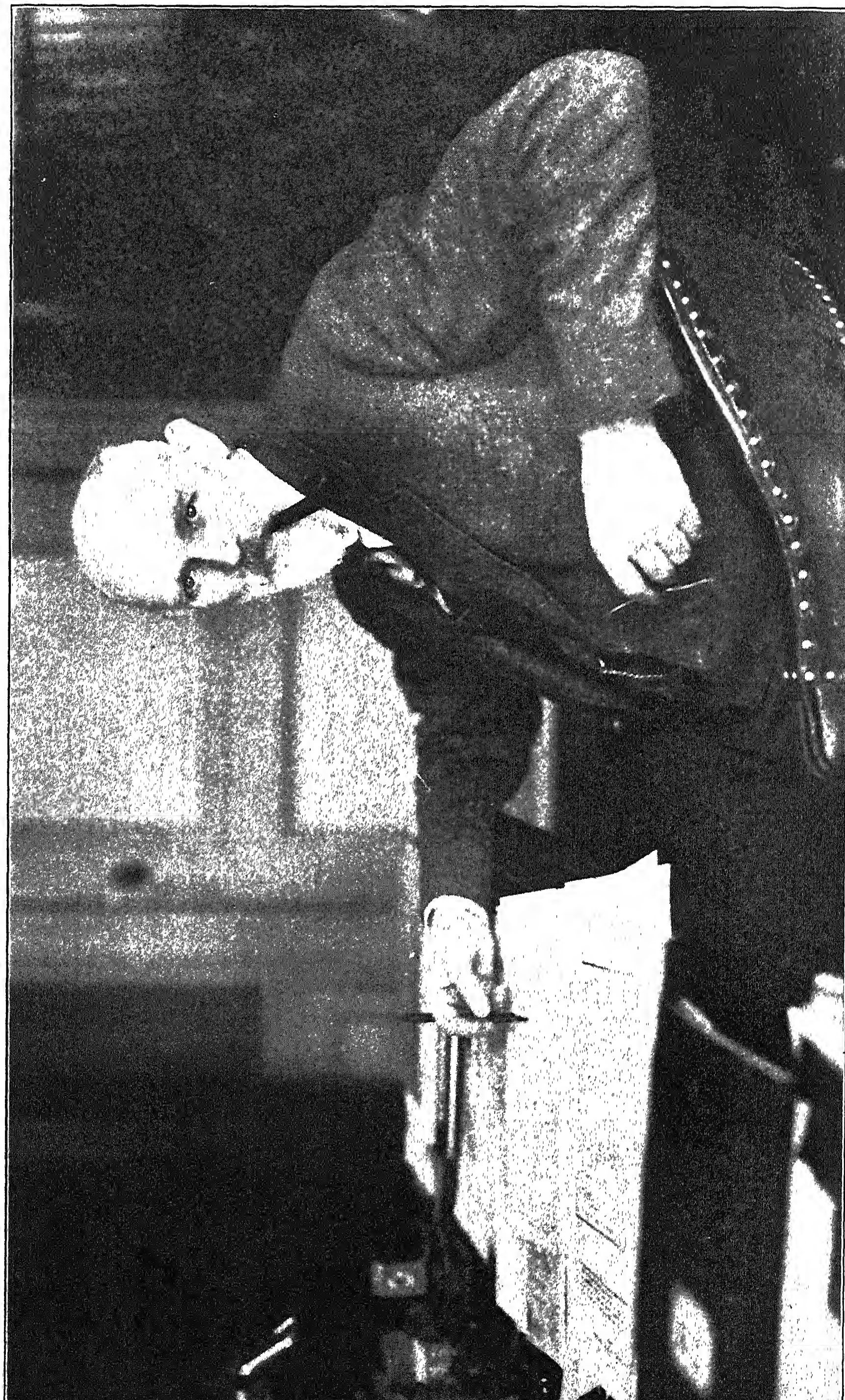
demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while courts will go a long way in admitting expert testimony deduced from a well-recognized principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field to which it belongs.

Briefly, here are the reasons for expecting Polygraph testimony to be admitted as evidence. In the first place, the instrument is known to be working with a very high degree of accuracy, and is gradually gaining "general acceptance in the particular field to which it belongs." To be admissible as evidence, however, it need only work with "a reasonable measure of precision in its indications." It need not be proved infallible. Professor Wigmore's "Treatise on Evidence" is the authority for that statement.

At the present time no one is compelled to submit to the Polygraph test. Consequently, if the science of detecting deception by this method is recognized, evidence obtained as the result of a voluntary submission would be admissible in court. Compulsory submission, however, raises another question.

There is, of course, a principle of constitutional law protecting an accused from unwillingly testifying against himself. As to what constitutes self-incriminating testimony is the subject of considerable legal speculation. Not everything obtained by compulsion is inadmissible. For instance, an accused person may be compelled to stand up in court for the purpose of identification; to place his feet in a suitable position for view by a jury; to make footmarks for the purpose of comparison with those found at the scene of a crime; to make finger-prints for the same purpose.

"Lie-detector" evidence is of a nature similar to that used in such cases. The Polygraph merely records reactions in a subject's blood-pressure and respiration, when asked questions pertinent to the crime under investigation. And the record is precisely the same even though the subject remains silent instead of replying by the usual "yes" or "no." Therefore, in view of the fact (1) that lay testimony is admissible concerning the physiological and psychological reactions of a person charged with a crime, about the time of its commission, or its discovery, or upon his arrest for or upon his accusation of it; and (2) that compulsory submission to a "lie-detector" test does not constitute "compulsory testimony" (if the analogy to the situations mentioned in the preceding paragraph is valid), it appears that an accused individual may even be forced to submit to the examination.



WILLEM DE SITTER

THE PROGRESS OF SCIENCE

WILLEM DE SITTER

THE death of Willem de Sitter on November 20 after an illness of only three days removes suddenly from the stage one of the leading actors in the drama of modern science. He was born on May 6, 1872, in the little town of Sneek in Friesland, Holland. He received his academic training at nearby Groningen in the years when Kapteyn, great astronomer and great teacher, was at the height of his creative powers. After leaving Groningen in 1897 the young astronomer was appointed assistant to David Gill, director of the Cape Observatory in South Africa. Of these two great men de Sitter never lost an opportunity to speak in terms of warmest gratitude. Appointment to a professorship at Leiden came in 1908, and to the directorship of the Leiden Observatory in 1919.

The field covered by de Sitter's contributions is an unusually wide one. At the Cape he gained experience in observing with the heliometer, in photographic photometry and in the measurement of positions on photographic plates. In these early years he became deeply interested in celestial mechanics, choosing for his specialty the theory of the motions of the four bright satellites of Jupiter, a subject that occupied much of his thoughts and energies to the very end of his life. At various times he concerned himself to good purpose with such problems as the earth's variable rotation, the evaluation of the fundamental constants of astronomy, and the determination of absolute star positions. When Einstein, his intimate friend through many years, published his general theory of relativity in 1916, de Sitter turned his attention to this subject. It is through this work that he became known in scientific circles and to the general public, although in the writer's opinion it is by no means his most important contribution. His picture of the cosmos became widely known as "the de Sitter universe." This like Einstein's is a static universe, and both have had to give way to one that takes account of the recession of the spiral nebulae, as revealed by the beautiful observations of Slipher at Flagstaff and of Hubble and Humason at Mount Wilson. The currently accepted view of an expanding universe is founded principally upon the work of Friedmann, Lemaitre and of de Sitter himself.

In an entirely different kind of effort de Sitter has made a first-magnitude contribution to astronomy. When he came to the directorship in 1919 he found the Leiden Observatory poorly equipped and even more poorly manned, the staff consisting of two or three assistants and as many clerks. To-day it is one of the leading observatories on the continent. He has gathered about him an exceptionally competent band of enthusiasts numbering about a score, with modern and adequate instruments at their disposal. Best of all he has known how to surround his staff with the atmosphere that makes for growth, and their contributions have played no small part in the recent astonishing developments of their science.

No account of de Sitter, however brief, can omit some mention of his home life. To say that a large part of his success is due to Mrs. de Sitter's devotion is not the platitude it may seem to be. Two sons and two daughters completed the happy circle. All six members of that household could (and did) read in the original the best that English, French, German and Dutch literatures afford, and other modern languages were familiar to at least one of

the group. It was a privilege and a pleasure to listen to the conversation of these intellectual aristocrats.

Although de Sitter's final illness was so brief, it did not come altogether as a surprise. About fifteen years ago he was given an overdose of ether while undergoing a major operation. Phthisis set in as a consequence, and he spent nearly two lonely years at Arosa in Switzerland. This cured him so far as immediate effects were concerned, but left a serious impairment, and the danger of pneumonia was never absent. It was this disease that finally overtook him and deprived the world of perhaps ten years of his great usefulness.

FRANK SCHLESINGER
DIRECTOR OF THE
YALE OBSERVATORY

AWARD OF THE NOBEL PRIZE IN CHEMISTRY TO PROFESSOR HAROLD CLAYTON UREY

FOR the second time in succession the award of the Nobel Prize in chemistry has been made to an American chemist. Harold Clayton Urey succeeds Irving Langmuir in the list of Nobel Laureates in chemistry. To both have come world-wide renown by reason of their scientific discoveries. Langmuir's star has shone now for many years with a steady brilliance which has illuminated many hitherto dark regions of the science. Urey's sun has risen, however, with a rapidity which is meteoric in character. Within three brief years, Urey's discovery that ordinary hydrogen gas was not simple, but contained a second isotope of mass 2, has penetrated to the farthest laboratories of the earth and has revolutionized programs of research not only in chemistry but in physics, experimental and theoretical, and in biology. Heavy hydrogen, the isotope with a name of its own, deuterium, has, during these three years, become the subject of upwards of three hundred scientific communications, released at an auto-accelerating pace.

The discovery of a new isotope of an element is not an unusual occurrence. Steadily, since the work of Aston on neon in 1919, element after element outside of the series of radioactive elements has been shown to be composite of two or more isotopes. The extraordinary recent discoveries had been the isotopes of oxygen and of carbon by Giauque and Johnston and by King and Birge, all of the University of California in 1929. These researches utilized band spectra as a new tool of analysis in the field of isotopes. They led to a calculation by Birge and Menzel that hydrogen must contain a heavier isotope, of mass 2 present to the extent of one part in 4,500. It was this prediction, together with considerations based on systematic arrangements of atomic nuclei which led Urey to his bold and successful efforts, in collaboration with Brickwedde and Murphy, experimentally to demonstrate the existence of such an isotope. The research was conducted in a manner which utilized to the full Urey's excellent theoretical equipment in statistical theory, in atomic and molecular spectra. The record of the work is a fine example of theoretical equipment as a powerful auxiliary to advanced experimental technique.

As is now well known, Urey, Brickwedde and Murphy utilized for purposes of concentration the distillation of liquid hydrogen, and attained approximately a fivefold concentration. The revolutionary character of the discovery only became apparent in the subsequent contribution by the late Dr. Edward W. Washburn and Urey, which demonstrated that electrolysis of aqueous solutions also enriched the residual liquor with the isotope of mass 2. They jointly recorded the importance of these results, pointing out that "we now know that

—*Ossip Garber Studios*

PROFESSOR HAROLD CLAYTON UREY

that there are large quantities of water in these electrolytic cells containing heavy hydrogen in relatively high concentrations and, also, there is available now a method for concentrating this isotope.'' Swiftly this conclusion was translated into reality. Within a year, heavy water, pure deuterium oxide, was an accomplished fact.

It was the ease with which the hydrogen isotopes could be separated that gave to Urey's discovery of deuterium much of its epochal character. For the first time it was now possible to examine the properties of two isotopes of an element in pure form and to verify ideas and theories which previously could only be tested with isotope ratios at best but slightly different from the normal. Especially in the field of molecular statistics and equilibrium, a field intensively developed by Urey in his subsequent researches, in problems of reaction velocity and mechanism, in problems of hydrogen and hydrogen compounds, notably water, including problems of

solutions, of biology and biochemistry, the utility of the separate isotopes was immediately demonstrated. Deuterium, indeed, was more important than a new element, since, by its aid, conclusions could be reached that held also, within limits, for hydrogen and were not obtainable with hydrogen alone.

Urey's discovery of the isotope was perfectly timed from the standpoint of science. It was revealed just as science was learning of the neutron and its properties, just as the nuclear physicist had learned to manipulate the proton as a high speed projectile for the transmutation of elements. Research immediately showed that the deuton was a far more interesting projectile than the proton. The spectroscopist, too, welcomed the isotope. Isotope effects in spectra are magnified when the mass changes by isotope replacement are in the ratio of one to two. Already the second order refinements of isotope effect in spectroscopy are under study with its aid. In theoretical physics and chemistry, also, in problems of nuclear structure, in problems of zero point vibrational energy and reaction speeds, the isotope became a powerful tool for calculation and subsequent test. In many aspects, Urey's discovery of deuterium may be compared with the discovery by Christopher Columbus of this continent. He revealed, for others to develop, a rich domain.

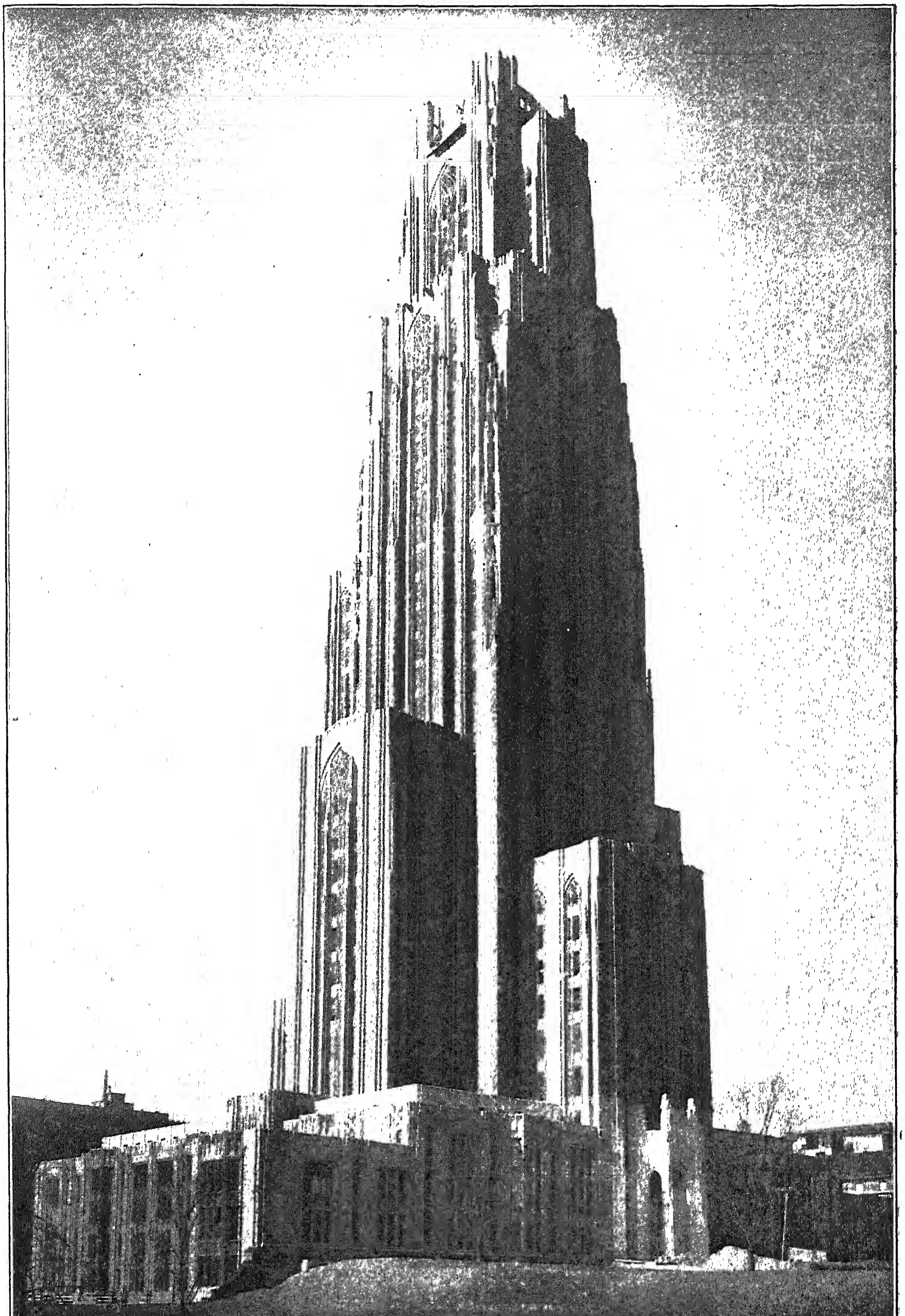
This year's Nobel Laureate in chemistry came out of the Middle West, having been born at Walkerton, Indiana, in April, 1893. A graduate of the University of Montana in 1917, he received the Ph.D. degree in chemistry from the University of California in 1923. The following year was spent in Copenhagen, where contacts with Niels Bohr served to complete his education in the mathematical and physical aspects of modern chemistry. From 1924 to 1929 he became one of a very active group of young research men associated with the chemistry department of Johns Hopkins University, whence he was called to Columbia University as a junior professor in 1929. Two years ago he became first editor-in-chief of the new *Journal of Chemical Physics*. Within the present year he has been promoted to a full professorship in chemistry at Columbia, has received the Willard Gibbs Medal of the American Chemical Society's Chicago Section and now joins the ranks of the scientific elect, the third American to win the Nobel Prize in chemistry.

HUGH S. TAYLOR
PROFESSOR OF PHYSICAL CHEMISTRY
PRINCETON UNIVERSITY

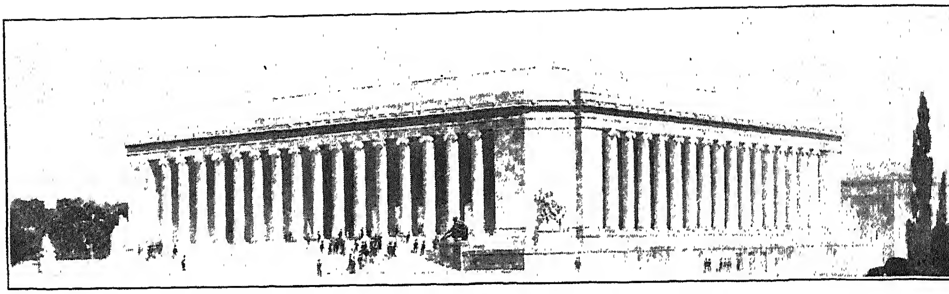
THE PITTSBURGH MEETING OF THE AMERICAN ASSOCIATION

THE ninety-fifth meeting of the American Association for the Advancement of Science, together with a large number of scientific organizations associated with it, will convene in Pittsburgh during the Christmas holidays. The meetings begin on Thursday evening, December 27, when the city and the institutions of Pittsburgh will extend an official welcome to their guests in the Carnegie Music Hall. Professor E. L. Thorndike, the distinguished psychologist, president of the association, in a brief address will respond for the visitors. A reception tendered by the Pittsburgh Local Committee will follow.

Pittsburgh has twice acted as host to the association; once in the summer of 1902, and again for the winter meeting in 1917–18. The registration for the latter meeting was only 492, while estimates for the coming one indicate that the attendance will be over 3,000. It seems especially appropriate that the meetings should be held in Pittsburgh, because it is a strong scientific center, especially in the field of the applied sciences. The University of Pittsburgh,



THE CATHEDRAL OF LEARNING OF THE UNIVERSITY OF PITTSBURGH



THE NEW BUILDING OF THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH

THE ENTIRE THIRD FLOOR OF THIS BUILDING WILL BE USED FOR THE SCIENCE EXHIBITION HELD IN CONNECTION WITH THE A. A. A. S. MEETING. GENERAL REGISTRATION WILL BE HELD HERE.

with its magnificent "Cathedral of Learning," the Carnegie Institute of Technology and the Mellon Institute of Industrial Research are among the host institutions.

Registration headquarters will be in the new building of the Mellon Institute, which opens its doors for the first time to a public gathering. This building will also house the science exhibition, which has recently become an important part of the annual meetings.

The various sections of the association and the societies meeting with it have a full series of papers on their programs. In addition, there are a number of general sessions and events of more than usual interest. Only a few of these can be mentioned here. Full information will be found in the official prelimi-

DR. R. D. CARMICHAEL

PROFESSOR OF MATHEMATICS, UNIVERSITY OF ILLINOIS; CHAIRMAN OF THE SECTION OF MATHEMATICS.

DR. HENRY G. GALE

PROFESSOR OF PHYSICS, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF PHYSICS.

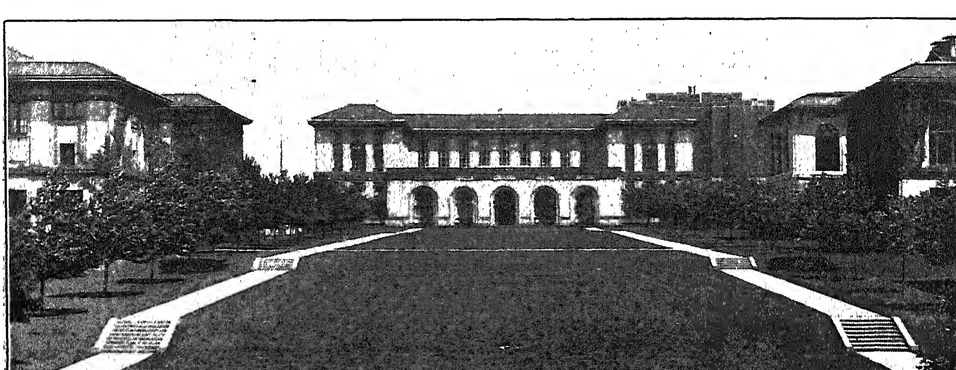
DR. JOEL H. HILDEBRAND
PROFESSOR OF CHEMISTRY, UNIVERSITY OF CALIFORNIA; CHAIRMAN OF THE SECTION OF CHEMISTRY.

DR. FREDERICK SLOCUM
PROFESSOR OF ASTRONOMY, WESLEYAN UNIVERSITY; CHAIRMAN OF THE SECTION OF ASTRONOMY.

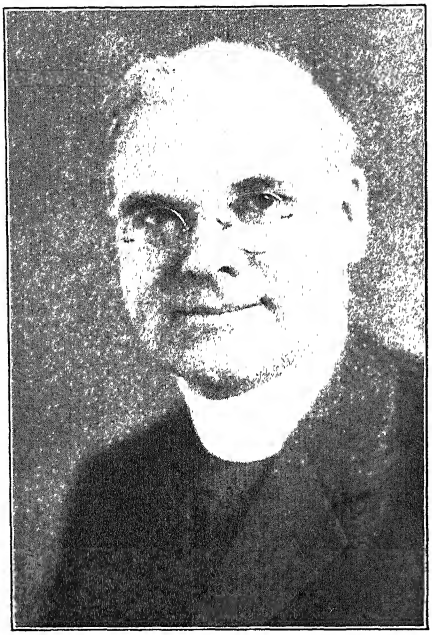
nary report published in *Science* for November 30 and in the official program, which will be distributed at the meeting.

On Friday evening the annual Sigma Xi address will be given by Professor E. A. Hooton, of Harvard University, entitled "Homo Sapiens, Whence and Whither." The address of Professor Arthur B. Lamb, also of Harvard University, retiring vice-president of the section on chemistry, will be delivered on the same evening. His subject will be "Crystallogenetic Adsorbents."

The Committee on the Place of



THE QUADRANGLE OF THE CARNEGIE INSTITUTE OF TECHNOLOGY
WITH THE COLLEGE OF FINE ARTS IN THE CENTER. PROFESSOR EINSTEIN WILL DELIVER HIS LECTURE IN THE LITTLE THEATER HOUSED IN THIS BUILDING.



DR. JAMES B. MACELWANE

Professor of Geophysics, St. Louis University; Chairman of the Section of Geology and Geography.

DR. BERNARD O. DODGE

Plant Pathologist, The New York Botanical Garden; Chairman of the Section of Botany.

DR. GEORGE L. STREETER

Director of the Department of Embryology, Carnegie Institution; Chairman of the Section of Zoology.

DR. MELVILLE J. HERSKOVITS

Associate Professor of Anthropology, Northwestern University; Chairman of the Section of Anthropology.

Science in Education is sponsoring an all-day symposium on Saturday. Among the speakers will be Professor Edward L. Thorndike, who will make an address on "The Psychology of Attitudes," and Professor Robert A. Millikan, who will speak on "The Present Status of Knowledge of Cosmic Rays."

On Saturday evening, Dr. C. F. Kettering, retiring vice-president of the section on engineering, will deliver his address in the Music Hall. This lecture will be preceded by an organ recital by Dr. Marshall Bidwell. The address of

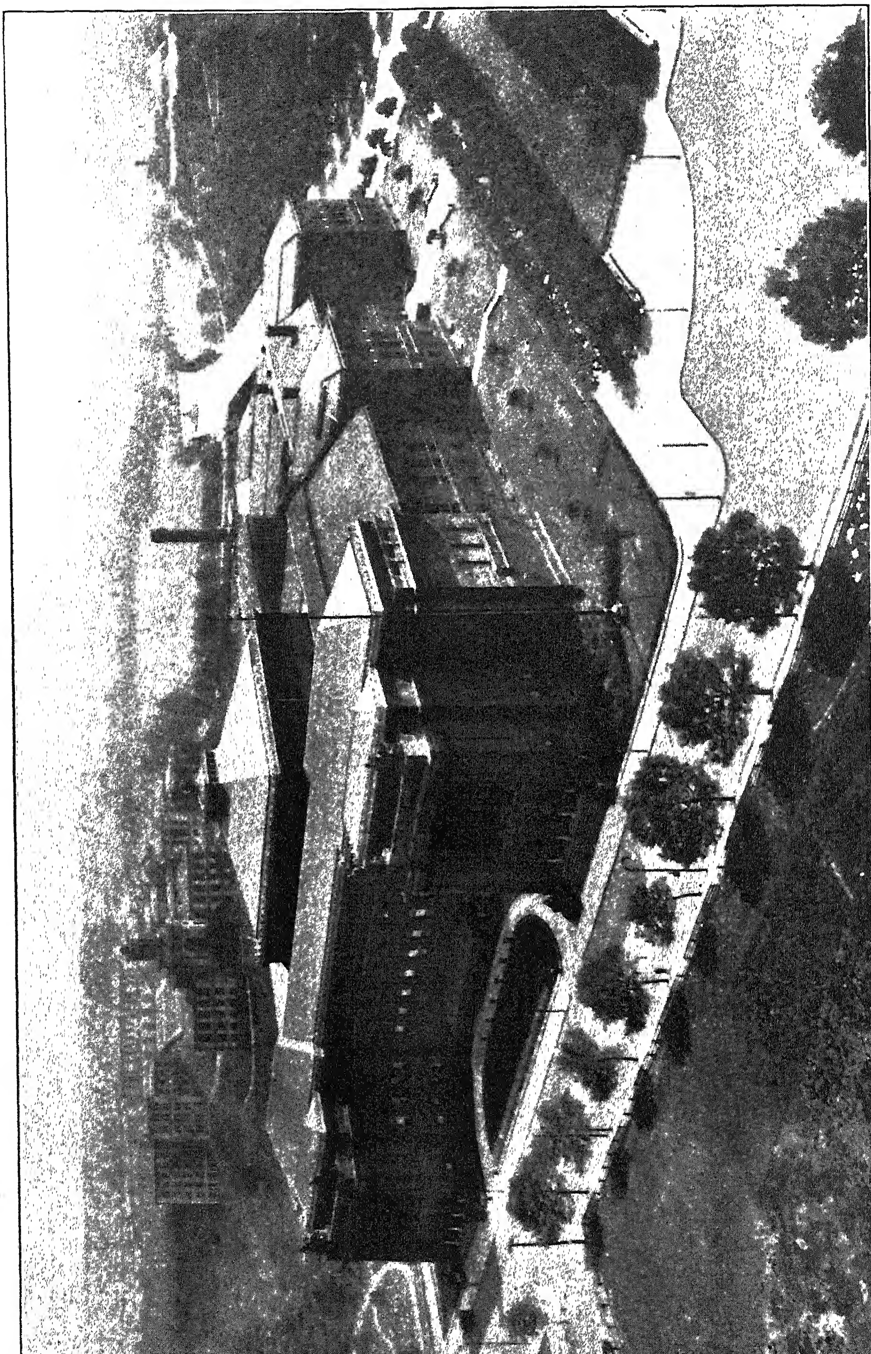
DR. JOHN E. ANDERSON
PROFESSOR OF PSYCHOLOGY, UNIVERSITY OF MINNESOTA; CHAIRMAN OF THE SECTION OF PSYCHOLOGY.

Dr. A. Franklin Shull, president of the American Society of Naturalists, on "Weismann and Haeckel—One Hundred Years," will also be given on Saturday evening.

On Sunday afternoon Dr. Phillips Thomas, of the research department of the Westinghouse Electric and Manufacturing Company, will give a lecture and demonstration known as "Ram-

CARL SNYDER
GENERAL STATISTICIAN, FEDERAL RESERVE BANK, NEW YORK; CHAIRMAN OF THE SECTION OF SOCIAL AND ECONOMIC SCIENCES.

DR. SOLON J. BUCK
PROFESSOR OF HISTORY, UNIVERSITY OF PITTSBURGH; CHAIRMAN OF THE SECTION OF HISTORICAL AND PHILOLOGICAL SCIENCES.



THE CARNEGIE INSTITUTE BUILDING

WHERE THE RECEPTION AND EVENING MEETINGS WILL BE HELD. THE BUILDINGS OF THE CARNEGIE INSTITUTE OF TECHNOLOGY ARE IN THE BACKGROUND.

DR. CYRUS C. STURGIS
PROFESSOR OF MEDICINE, UNIVERSITY OF MICHIGAN; CHAIRMAN OF THE SECTION OF MEDICINE.

DR. JACOB G. LIPMAN
PROFESSOR OF AGRICULTURE, RUTGERS UNIVERSITY; CHAIRMAN OF THE SECTION OF AGRICULTURE.

DR. C. E. SKINNER
ASSISTANT DIRECTOR OF ENGINEERING, WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY; CHAIRMAN OF THE SECTION OF ENGINEERING.

DR. GUY T. BUSWELL
PROFESSOR OF EDUCATIONAL PSYCHOLOGY, UNIVERSITY OF CHICAGO; CHAIRMAN OF THE SECTION OF EDUCATION.

blings in Research'' at the Carnegie Music Hall. In the evening the symphony orchestra of the department of music at the Carnegie Institute of Technology will join with Dr. Bidwell in a special recital for members of the association.

Monday evening will be devoted primarily to the address of the retiring president of the association, Dr. Henry Norris Russell, research professor of astronomy at Princeton University, who will speak on ''The Atmospheres of the Planets.'' Of special interest in the mathematical program will be the address of Professor Albert Einstein, who will deliver the annual Josiah Willard Gibbs lecture of the American Mathematical Society. This lecture, the eleventh of the series, will be delivered in the Little Theater of the Carnegie Institute of Technology.

A series of special lectures will be given in the afternoons including a lecture on Thursday by Dr. Cyrus C. Sturgis, director of the department of internal medicine at the University of Michigan. He will review ''Some of the More Important Recent Advances in the Study of Blood Diseases.'' On Friday Professor H. H. Newman, of the University of Chicago, will give a lecture on ''Twins Reared Apart and the Nature-Nurture Problem.'' Dr. Mark H. Liddell, of Purdue University, will speak on Saturday on ''The Auditory Spectrum,'' when Professor C. T. Knipp, of the University of Illinois, will conduct experiments with his singing tubes as a part of the demonstration.

A symposium on the relation between science—and especially scientific organizations and institutions—and the press will be held in the Hotel Schenley on Sunday morning. Speakers from leading universities will outline the policies and problems of their institutions, and representatives of the National Association of Science Writers, Science Service, the Associated Press, the Hearst Service and several outstanding newspapers will give the association the benefit of their experience and outline the newspaper point of view.

On Friday the sections of chemistry and physics will hold an all-day joint meeting to discuss ''Heavy Hydrogen and Its Products.'' Mathematicians and physicists will hold a symposium on Saturday morning to discuss the ''Group Theory and Quantum Mechanics.'' Several joint meetings have been planned by the section on zoological sciences and also by the botany group. ''Science and Technology in Western Pennsylvania'' will be the topic of a discussion to be held by the section of historical and philological sciences in conjunction with the section on engineering. A program of addresses of general interest on certain aspects of contemporary economic and social problems under the New Deal is being arranged by the section on social and economic sciences.

The science exhibition will include demonstrations on cosmic ray research contributed by Dr. Robert A. Millikan and Professor A. H. Compton and their associates; displays of the work on deuterium of several laboratories, with a contribution from Professor Harold C. Urey; a model of the stratosphere balloon gondola and its instruments; a model of the Van de Graaff 15,000,000-volt electrostatic generator; and many others of general interest both to the general public and to workers in science.

W. N. J.

THE SCIENTIFIC MONTHLY

FEBRUARY, 1935

THE SURFACE FEATURES OF THE MOON[1]

By F. E. WRIGHT

GEOPHYSICAL LABORATORY, CARNEGIE INSTITUTION OF WASHINGTON

THE moon needs no introduction. It has been known to all of us from early childhood when we first tried to reach out and touch it and later learned to decipher both the man and the lady in the moon. In spite of this general interest and friendly feeling toward the moon, the president of the Carnegie Institution of Washington realized several years ago that its presence in the night sky is resented by the modern astronomer, especially the astrophysicist. Its light interferes with the photography and analysis of far distant, faint celestial objects, such as stars, clusters and nebulæ—incandescent masses of enormous size, radiating huge amounts of energy into space and of special significance because they yield information on the extent of the universe and on the behavior and structure of matter under conditions of temperature and pressure not attainable in the laboratory. These remote, active heavenly bodies appeal to the imagination and offer problems of the most fascinating kind for solution. The astrophysicist is occupied with receiving and interpreting their messages. He learns little in this field from the moon. To him it is a lifeless, inert mass, shining only by reflected sunlight and held by gravitation in its orbit about the earth. From an astronomical viewpoint the moon is an insignificant object only 2,160 miles in diameter; the sun is nearly a million (864,000) miles in diameter. To us the moon appears large because it is distant only 30 earth's diameters or 240,000 miles. Viewed through a large telescope it appears to be only 200 or 300 miles away and details 500 feet apart can be distinguished under conditions of good seeing.

To the layman, not versed in astrophysics, the moon is the most conspicuous object in the night sky and the rival of all heavenly objects, even including the sun itself. It has played a significant part in many phases of human activity. To it we owe the first subdivision of the year into months and weeks, even though in our present calendar the lunar cycle is disregarded. The words moon and month are derived from the same Sanskrit root, *mâs*, meaning to measure. To our primitive ancestors the moon was an object of worship; they observed and tried to explain its changes in aspect and in position among the stars from day to day. Together with the sun it is responsible for the tides, so important to navigation. Its light illuminates the sky at night during a part of each month and its moonbeams are said to be an important factor in certain human decisions. To the formulation of the law of gravitation and to

[1] This article presents the progress made by the Committee on Study of the Surface Features of the Moon of the Carnegie Institution of Washington, of which the author is chairman.

the development of dynamical astronomy it contributed much; but to modern astrophysics it has added little and it can not compete with other heavenly bodies as an object of study. The astronomer of to-day does not appreciate the moon as did Milton when he wrote in "Paradise Lost":

> . . . The moon
> Rising in clouded majesty, at length
> Apparent queen, unveiled her peerless light
> And over the dark her silver mantle threw.

In 1609 Galileo first observed through his telescope the surface features of the moon, its craters, mountains and great plains or seas, as he called them. Realizing that the moon is a companion of the earth and, as he thought, a world not unlike our own, he was impressed by the features which he saw; and sought to interpret them in terms of terrestrial features. To him and to his contemporaries his telescope seemed to disclose a new world. Following his lead, astronomers undertook serious study of the moon's surface. During the next three centuries a vast amount of observational data on lunar surface features was accumulated and many lunar maps were published. As a result, the geography or rather selenography of the moon is well known; no part of the moon's surface visible to us has been left unexplored. Furthermore, selenologists have sought to explain the mode of formation of the different features on the moon's surface and have suggested all manner of hypotheses to account for them. In spite of all this labor we do not yet know definitely the exact nature of the lunar surface materials, nor how any single lunar feature was formed. No critical study and classification of lunar surface features have been made and no lunar maps free from the personal factor have been prepared.

Cooperative Approach

At the time the Committee on Study of the Surface Features of the Moon was appointed, Dr. John C. Merriam felt that attack by a cooperative Carnegie Institution group might be fruitful of results, especially if the experience from several branches of science could be brought to bear upon it. Accordingly, he chose for membership on the committee four astrophysicists, one mathematical physicist, one geophysicist and two geologists.[2] The committee was given no specific instruction other than that implied in its title; it was afforded opportunity to contribute toward the solution of a most attractive problem, in part astrophysical, in part geological.

This policy of assigning to an interdepartmental committee a problem of large scope is in keeping with the general policy of the Carnegie Institution of supporting organized efforts in fields of science too large for one man to encompass. In the early days of science it was possible for one person to master all existing knowledge in his own field; advances were then made chiefly through the efforts of individual scientists working alone. These men laid the foundations on which modern science is being built. Each department of the Carnegie Institution is essentially a group of cooperating scientists, each member carrying on research activities of his own, but also doing his share of cooperative work. This group method of facing each problem from all standpoints and determining the best means for solving it is followed not only within each group, but also between the several groups within the institution and between the institution and outside agencies. The dividends accruing from cooperative work of this kind, in terms of scientific results obtained for a given sum of money, are

[2] Members of the committee are: W. S. Adams, F. G. Pease and E. Pettit, of Mt. Wilson Observatory; A. L. Day and F. E. Wright (chairman), of the Geophysical Laboratory; and research associates, H. N. Russell, of Princeton University, J. P. Buwalda and P. Epstein, of the California Institute of Technology.

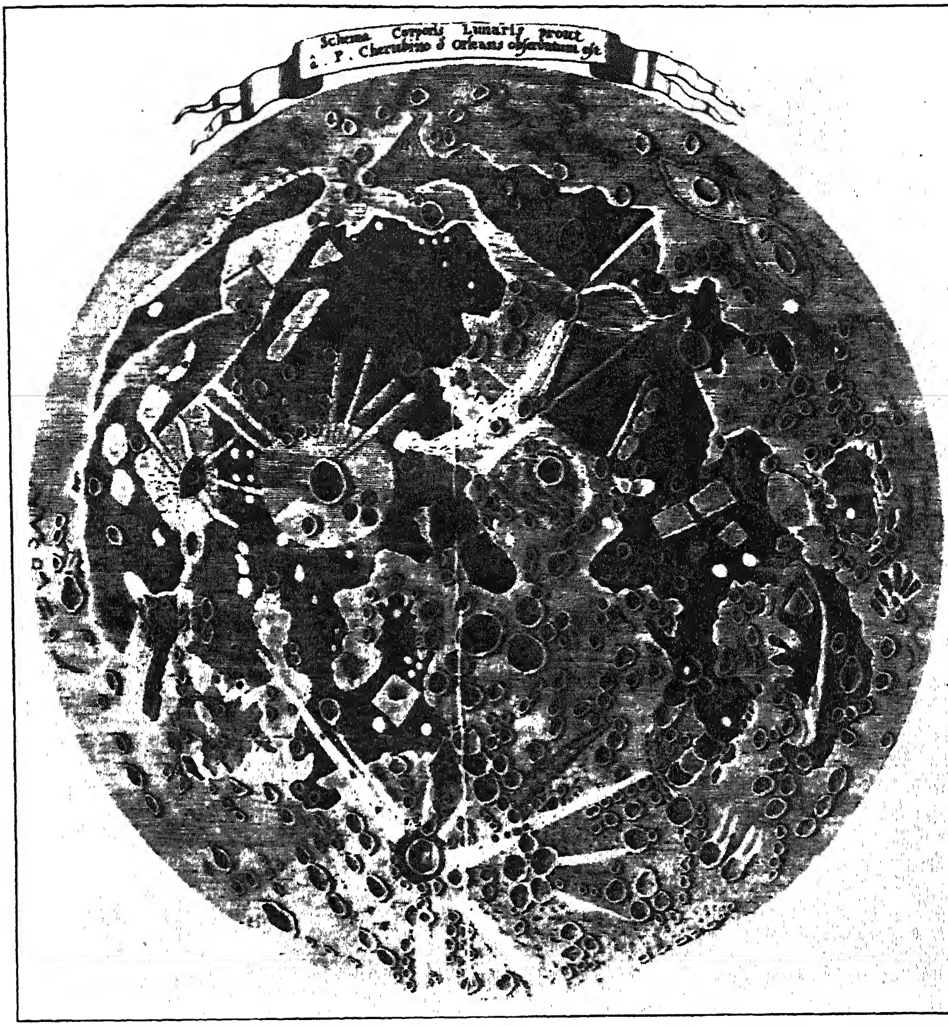


FIG. 1. EARLY SKETCH MAP OF THE MOON
PREPARED BY P. CHERUBINO D'ORLEANS. PUBLISHED IN THE BOOK, "OCULUS ARTIFICIALIS TELEDIOPTRICUS SIVE TELESCOPIUM," BY J. ZAHN. NORIMBERGAE. 1702. REPRODUCED THROUGH THE COURTESY OF DR. J. C. HOSTETTER, CORNING, N. Y.

unusually large, chiefly because of facilities and the background of experience within the several groups. Were it not for this factor, the special interdepartmental and other cooperative activities would be less successful. On the other hand, the drawback to committee work of this nature is that no member can devote much time to it; results are, therefore, gathered slowly and the effort is spread over many years.

PRELIMINARY SURVEY

As a preliminary to experimental work on the problems presented by study of the surface features of the moon the committee undertook to survey the field and to analyze the present status of the problem. It sought to visualize the conditions existing at the moon's surface. The observer can not journey to the moon and gather samples, make maps and plot the field relations

on the spot. In geological field work geologists have become accustomed to judge of the relative effectiveness of different terrestrial agencies and are inclined to interpret what they see in terms of terrestrial factors or processes with which they have had experience. Moreover, the geologist sees what he has been trained to see and overlooks much that he would otherwise see had he the necessary background of experience. In study of the surface features of the moon he is confronted with conditions with which he has had no contact. Lunar surface features have been sculptured by catastrophic agents of different kinds and not by the action of running water, or by erosion and deposition in the usual sense, or by ordinary wind action, or by weathering. Gravity is only one sixth of that on the earth; a mass of rock weighing a ton on the earth would weigh only 333 pounds on the moon. At the moon's surface there is no water, no ice; no protective blanket of atmosphere to soften the impact of the sun's rays and to prevent the escape of heat radiated from the moon's surface. The temperature ranges are extreme. At midday on the moon, with the sun directly overhead, the surface temperature is approximately 120° C. (250° F.) or above that of boiling water; at midnight it falls to below –100° C. (–150° F.). In spite of this extreme range in surface temperatures it is probable that a few feet below the lunar surface the inflow of sun's radiation maintains a temperature not far from freezing, or 0° C.

It is not an easy task for the geologist to adjust his mental attitude to such extreme conditions. He has become accustomed, on viewing a given terrestrial surface feature, to inquire: (a) of what kinds of rocks or materials does it consist; (b) what geological agents, operating on the original rock mass, have given the surface feature its present shape? He has learned to recognize the imprint or earmark of each kind of geological agent and seeks in a given case to ascertain what combination of geological agents or processes, acting one after the other or together, have produced the surface feature under study. By this method he is able to read and to interpret geological history as it is written in the rocks and on their surface. In his study of the surface features of the moon he is confronted with physiographic forms which, in part, are quite unlike anything he has seen on the earth; also, he misses the familiar effects of erosion. To him the surface of the moon presents a weird picture. He realizes that before he can begin to make progress on lunar physiographic problems, he must first ascertain the nature of the materials which he sees exposed on the moon; then determine how those materials behave under the known lunar surface conditions. In other words, he must acquire a good working knowledge of the petrology of the lunar surface materials. In addition he needs a good lunar map, preferably a topographic map, by use of which he can obtain an idea of the spatial relations of the different features. This is asking a good deal and the task might seem hopeless were it not for the fact that messengers are continually reaching us from the moon in the form of reflected sun's rays; they will teach us much if we can decipher and interpret their messages correctly.

The Moon's Surface

The general features of the moon's surface are shown in Figs. 2 to 4. The dark smooth areas of Figs. 2 and 4 are called seas or maria; the lighter areas bordering the maria are the mountains; the features of circular outline are called craters because of their resemblance to terrestrial craters. The craters dominate many parts of the moon's sur-

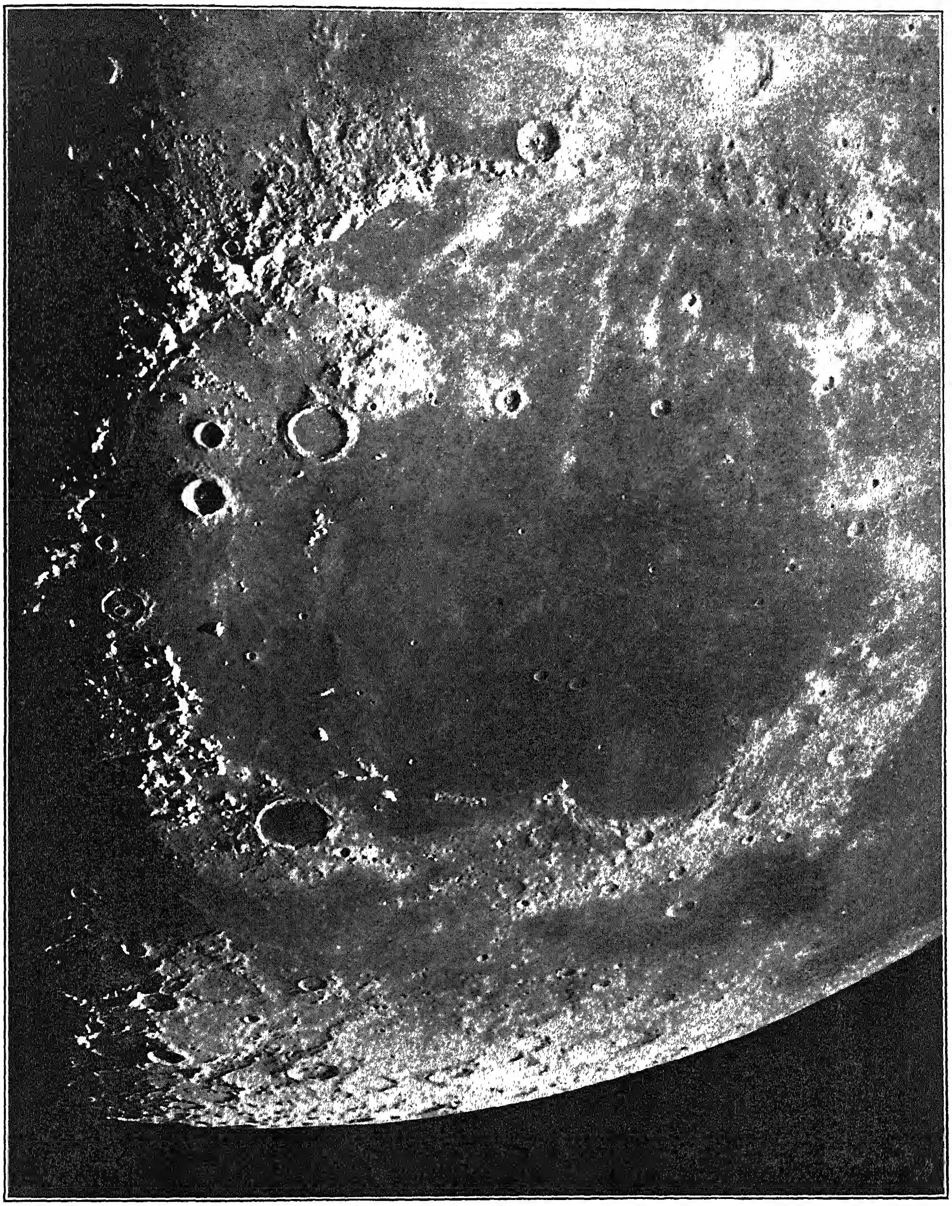


FIG. 2. NORTHEAST PORTION OF MOON'S SURFACE

MARE IMBRIUM OCCUPIES THE CENTRAL PART OF THIS VIEW. IT IS 800 MILES ACROSS AND IS BORDERED BY HIGH MOUNTAINS OF STRANGE ASPECT. OBSERVE THE DIVERSITY IN SIZES AND CHARACTERISTICS OF THE CIRCULAR FEATURES OR CRATERS. (PHOTOGRAPH BY F. G. PEASE, MT. WILSON OBSERVATORY, SEPTEMBER 15, 1919.)

face and are remarkable for their range in size and for their frequency. Of small craters there are literally thousands spread over the surface of the moon. The larger craters greatly exceed in dimensions terrestrial craters. Many of the craters, located in the maria, have smooth floors, level with the ground of the surrounding country; other craters are much deeper and less smooth; in many of these craters there is a central hill or series of peaks which rise from the crater floor; on several of these peaks there is perched, in turn, a small crater (Fig. 3). The area covered by a mare is greater than that of any one of the great plains regions of the earth. Mare Imbrium, which occupies the central portion of Fig. 2, is 800 miles across. The maria are relatively late formations and spread, as floods over preexisting craters and other features, submerging them either completely or nearly so.

One of the most impressive craters on the moon is Copernicus (Fig. 3); it is 56 miles across and 13,500 feet deep, about as deep as Mt. Blanc is high, and with central hills rising 2,400 feet above its floor. The simplest method for measuring the elevation of a lunar feature above the adjacent country is to ascertain the length of its shadow when it is near the terminator or the limit of illumination across the moon's disk. We know at any given time and for any point on the moon's surface the angle which the sun's rays make with the vertical to the moon's surface at that point, so that it is a simple task to compute from the given angle and the length of the shadow the height of the feature casting the shadow. Another method is based on the shift in longitude relations between adjacent features of different elevations with changes in libration. Still another method is the stereoscopic method, which also is based on phenomena due to libration. The terraced inner walls of Copernicus are conspicuous; also the rays or streaks which emanate from it and extend for great distances across Mare Imbrium. The most pronounced rays, however, radiate from Tycho (Fig. 4); this crater is 54 miles across and 17,000 feet deep; a central hill rises 5,200 feet from its floor. It is located in a part of the moon which is dominated by craters large and small and of different ages. The more recent craters are more sharply outlined and are lighter in color, as a general rule. Not far above Tycho in Fig. 4 is located Clavius, a magnificent crater 142 miles in diameter, 17,000 feet deep, and containing smaller craters, one of which is larger than any terrestrial crater. In this figure also a fault scarp is shown in the mare below Tycho which is called the Straight Wall; it is 70 miles long with a downthrow of nearly 1,000 feet on the east.

Study of the mountainous areas in the photographs and on other parts of the moon shows that they are unlike terrestrial mountains and are for the geologist and the astronomer exceedingly difficult to interpret. The heights of the mountains reach 25,000 feet in isolated cases; the deepest crater has a depth of 24,000 feet. The lunar mountains are extremely rough and would be difficult to traverse, even if there were water and air present to support life. This is not the place to discuss the many hypotheses which have been suggested to account for the mode of formation of the different types of lunar surface features. Suffice it to state that no single hypothesis has been adequately proved so that it can be accepted without reservations. Each hypothesis contains certain elements of truth. With reference to the volcanic theory of the origin of the craters, the observed intimate relationship between lunar crustal structure and the occurrence of craters indicates that some of the craters, at least, are due to volcanic action. On the other hand, the

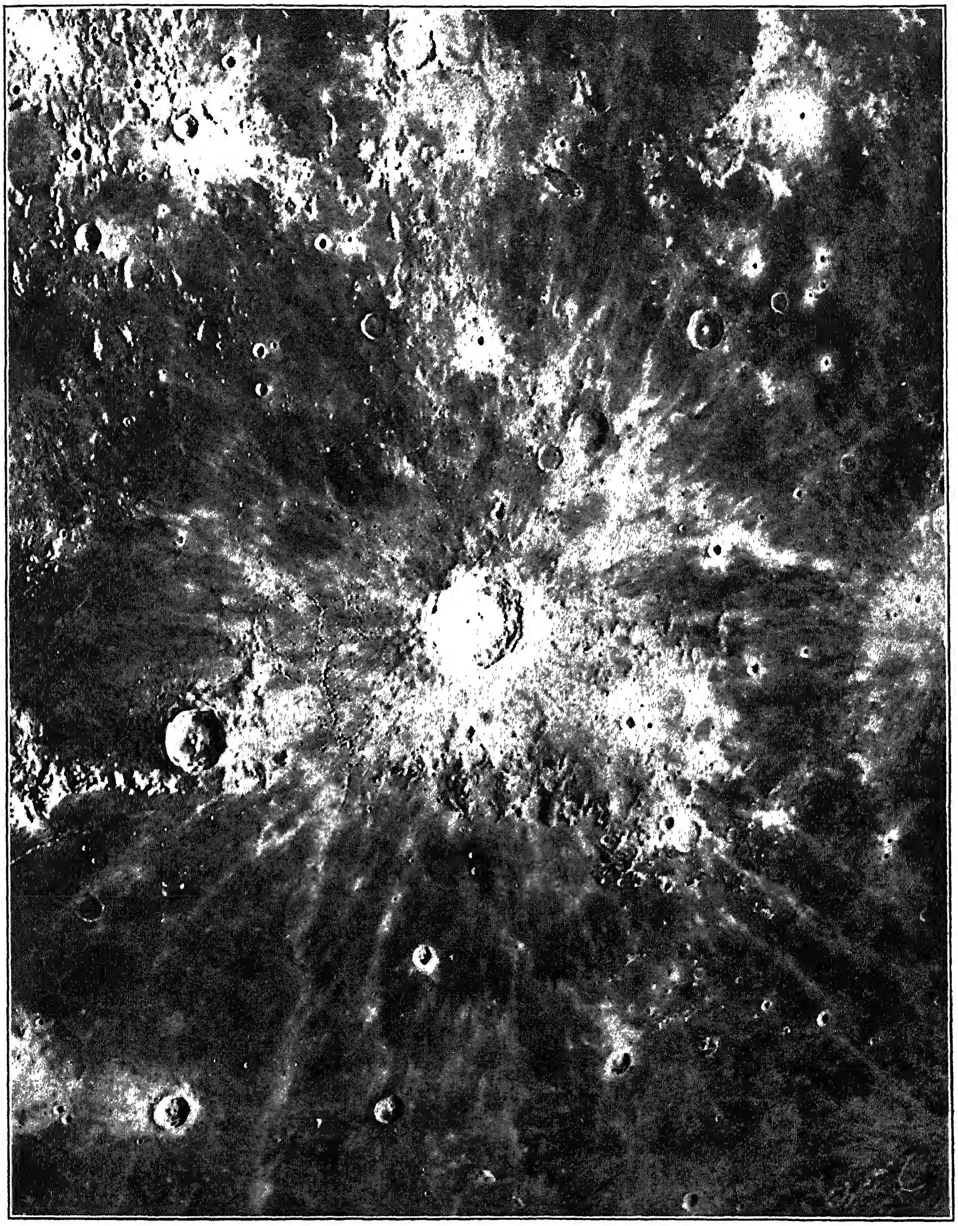


FIG. 3. EAST CENTRAL PORTION OF MOON'S SURFACE

COPERNICUS IS A MAGNIFICENT CRATER 56 MILES ACROSS AND DOMINATES THIS "METROPOLITAN" AREA OF THE MOON. OBSERVE THE STREAKS OR RAYS OF LIGHT MATERIALS WHICH RADIATE FROM COPERNICUS. (PHOTOGRAPH BY F. G. PEASE, MT. WILSON OBSERVATORY, SEPTEMBER 15, 1919.)

translational energy of a meteor impinging unimpeded on the moon with a velocity of 20 to 40 kilometers a second and penetrating into the surface for some distance is able not only to produce the crater form, but also on transformation of the residual kinetic energy into heat to melt and even to volatilize the country rock and thus set up actions which in their effects would closely resemble volcanic phenomena. In this connection the low lunar gravity is an important factor.

From a geological standpoint the absence of water and air on the moon together with its low gravity are factors favorable to the development and maintenance of extremes in surface forms. One of the results of low gravity and the lack of air resistance is the greatly increased length, 25 to 50 fold, of trajectories of materials thrown out of lunar craters as compared with the trajectories of materials ejected at the same initial velocity and angle of elevation on the earth. For a muzzle velocity of 1,600 meters (5,250 feet) per second, equal to that of the Big Bertha gun which the Germans used against Paris during the world war, the terrestrial range for an elevation angle of 50° is 75 miles; on the moon the maximum range for this initial velocity is 2,200 miles, or more than one quarter of the distance around the moon. The rays from Tycho have been traced for approximately 1,500 miles; for this distance an initial velocity of 1,480 meters (4,856 feet) per second is required and an elevation angle of 26°. An initial velocity of ejection from terrestrial volcanoes exceeding 2 kilometers a second has been deduced from observations of the volcano Cotopaxi. It is evident, therefore, that the ranges of ejection on the moon can easily have been produced by volcanic explosive forces comparable to those active on the earth. On the moon the materials ejected from a lunar crater are scattered far and wide, whereas on the earth the greater part of the ejected rock fragments and blocks fall near and into the crater orifice. As a result of this dispersion the lunar craters are cleaned out as a rule and are of the nature of deep holes in the ground with the floor of the crater below the level of the surrounding country; the floors of terrestrial craters, on the other hand, are near the top of the crater and high above the level of the adjacent country. This is one of the factors to be taken into account in a study of lunar craters. It is not permissible to conclude that, because the shape of a lunar crater is similar to that of a terrestrial crater the mode of formation of the two was the same.

Mapping the Moon

Before the geologist can make satisfactory progress in lunar physiographic studies he must have a topographic map, at least of the central portion, to aid him in visualizing the shapes of the lunar surface features and of their relations one to another. He can then classify the features, and by studying them in detail can acquire a background of experience in lunar geology which is necessary to competent interpretation of the phenomena observed.

Of maps there are two kinds, the plan or base map and the topographic. Thus far, for the moon, only the first kind has been attempted. It represents the moon's globular surface projected on a definite plane and shows the features somewhat as the astronomer sees them through his telescope. These maps have been drawn by astronomers untrained in the principles of map-making, with the result that existing maps are unsatisfactory in several respects; the balance between map scale and amount of detail shown is not realized and some of the maps are not easily legible; several lunar maps have been prepared by men

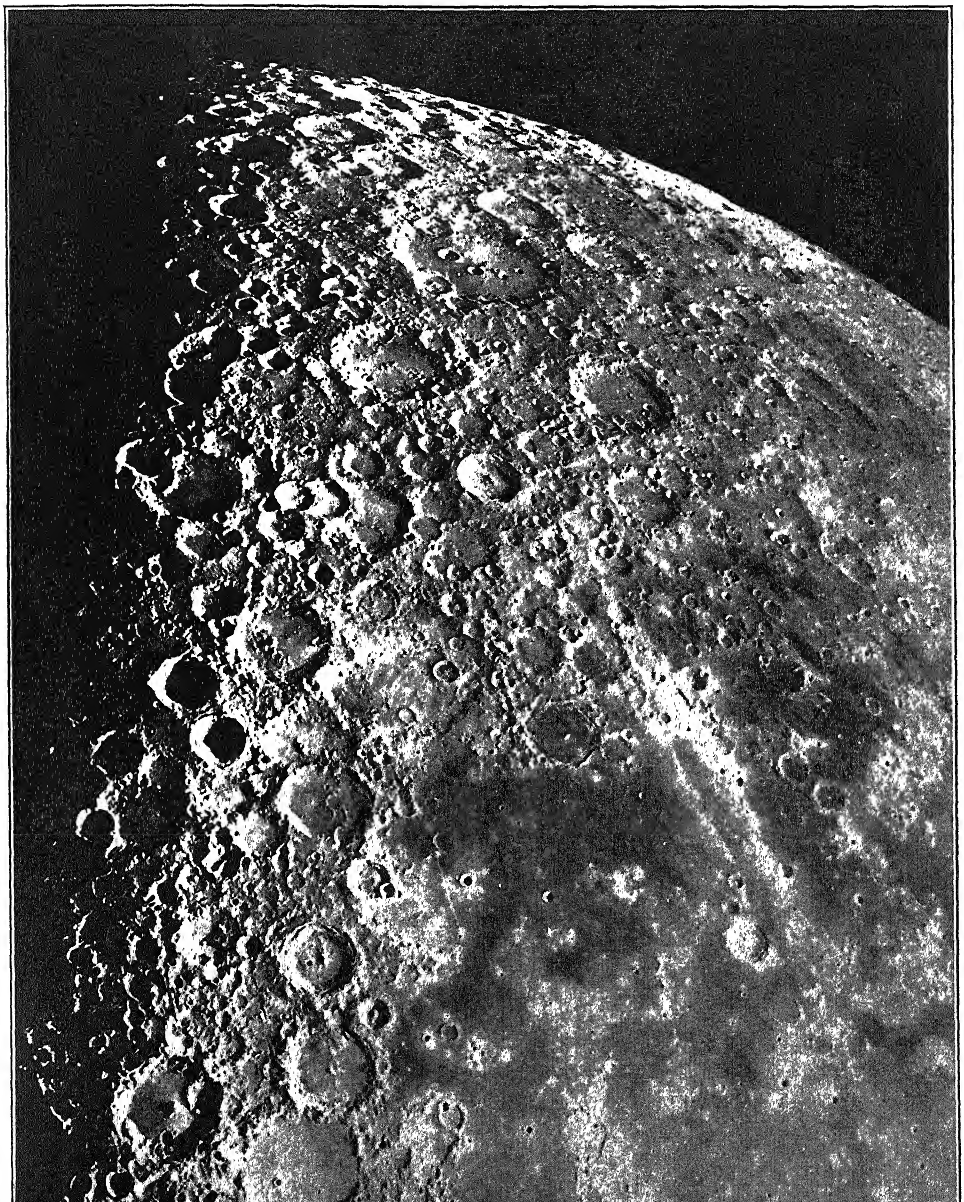


FIG. 4. SOUTHEAST SECTION OF MOON'S SURFACE

The large, sharply defined crater near the center of the view is Tycho. It is 17,000 feet deep and 54 miles across; from it white streaks radiate for long distances. Clavius, a still larger crater, 142 miles in diameter and located above Tycho, is one of the most interesting features on the moon. (Photograph by F. G. Pease, Mt. Wilson Observatory, September 15, 1919.)

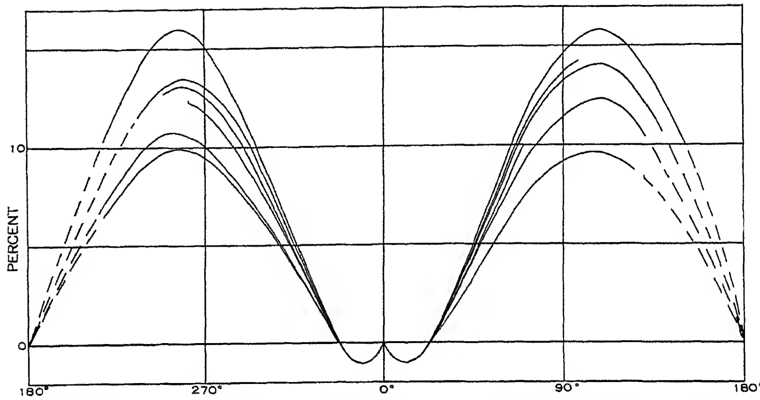


FIG. 5. CHANGE IN PLANE POLARIZATION OF MOONLIGHT FROM MARIA
THE CURVES SHOW THE CHANGES IN PERCENTAGE PLANE POLARIZATION OF MOONLIGHT FROM DIFFERENT LUNAR MARIA WITH CHANGE IN PHASE ANGLE.

who were good observers, but not good draughtsmen and unable to portray what they saw. In other words, the existing maps suffer from the personal equations of the men who drew them. Comparison of a lunar map made a century ago with one made recently shows marked differences in the representation of certain features; on the basis of such a comparison it has been concluded that changes have taken place here and there on the moon. But astronomers do not agree as to the validity of any single change, and the bulk of the available evidence goes to show that there has been no appreciable change on the moon's surface within the past century.

It seemed, therefore, to the moon committee that a lunar map should be prepared which is free from the personal equation and not dependent on the skill of the observer to depict correctly what he sees on the surface of the moon. The positions of approximately 4,000 points on the moon's surface have been accurately measured by Saunders, Franz and others and expressed in terms of selenographic longitude and latitude. With the aid of these data on position it is possible to ascertain the amount and direction of libration in each photograph of the moon. If each photograph could be transformed so that its plane coincides with the plane of mean libration, namely, the plane on which all lunar maps are projected, the transformed photograph would form part of a lunar map and at the same time be free from the personal equation of the one who makes the map. To prepare a photographic map of the moon it is necessary to transform photographs taken with the aid of the 100-inch telescope at Mt. Wilson so that the plane of projection is the same for all photographs. A map is a projection on a definite plane; the type of projection and the plane of projection must be quite definite if the map is to be satisfactory. For the transformation of the photographs a special moon house has been built at Mt. Wilson. It is a specially insulated structure with double walls, corrugated sheet iron on the outside and paper on the inside with ventilation between the walls so that they quickly respond to temperature changes outside. The floor is covered with a layer of sawdust six inches thick to prevent radiation from the ground. As a result, the temperature distribution within the 150-foot building is remarkably uniform and seeing conditions are good so long as the temperature outside is not changing rapidly and there is no appreciable wind.

To transform a given moon photo-

graph taken at the Cassegrain focus of the 100-inch telescope (focal length 135 feet), the moon positive, 15 inches in diameter, is mounted in front of a powerful beam of light reflected by an Army searchlight mirror 3 feet in diameter; the light passes through the positive to a parabolic silvered mirror of 67.5 feet focal length and 135 feet distant and thence back to a carefully turned globe of bronze, 15 inches in diameter and coated with magnesia powder. This coating furnishes a white diffuse reflecting surface. The image of the moon formed on it is in all respects similar to the moon in the relations of the surface features one to the other; in other words, it is a miniature moon which can be photographed from any direction. For this purpose a second reflecting mirror, also of 67.5 feet focal length, is placed at such a position that it views the moon from the direction of mean libration and casts an image of it on a photographic plate mounted in a compartment beside the illuminated globe. The photographs thus produced are projections on the plane of mean libration; they fulfil the requirements of a map on a given scale. In order to complete the series of maps showing the moon at different phases we still need photographs taken with the 100-inch telescope and its zero corrector lens. During the past two years the seeing conditions at Mt. Wilson have not been such that we could obtain photographs of the quality desired for this purpose. The series of maps made by this method will be independent of the personal factor and be more valuable a century hence than at present.

Photograph of Moon on Globe

The projection of the moon positive on the magnesia-coated globe gives a surprisingly beautiful and realistic representation of the moon's surface. The correct and undistorted appearance of the craters and other features near the edge of the moon's disk is of great aid in the visualization of the surface relationships. In order to make this globular representation more accessible, a glass globe coated on the outside with photographic emulsion was substituted for the magnesia-coated bronze globe and the moon negative projected on it, thus producing a moon transparency which is angle true. The globe is frosted on the inside and illuminated by an electric bulb. The coating with photographic emulsion was done, through the courtesy of Dr. C. E. K. Mees, by the Research Laboratory of the Eastman Kodak Company, and represents a new advance in photographic technique. A

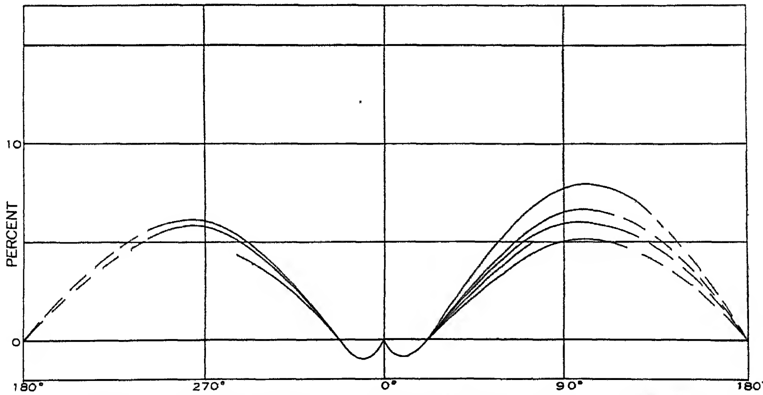


FIG. 6. CHANGE IN POLARIZATION IN MOONLIGHT FROM MOUNTAINS

THE CURVES SHOW THE CHANGES IN PERCENTAGE PLANE POLARIZATION OF MOONLIGHT FROM DIFFERENT MOUNTAINOUS AREAS WITH CHANGE IN PHASE ANGLE.

dozen of these globes have been prepared; they will be useful to the moon committee in its physiographic work later; they may also serve as exhibits of miniature moons showing the moon at different phases.

The committee has also devised a method for making a topographic map of the central part of the moon out to 45° from the center and with contour intervals of 500 feet or 200 meters. For the preparation of this map advantage is taken of the libration of the moon to obtain stereoscopic images from which, in turn, the relative elevations can be ascertained by applying the principle used in areal mapping from airplane photographs; with this difference, however, that in airplane mapping the surface of reference or datum plane is a horizontal plane, whereas on the moon we are interested in the elevations with reference to a mean spherical surface. The apparatus has not yet been built, and we shall not stop to consider details of the method.

Surface Composition

We come now to the problem of ascertaining the nature of the materials exposed at the surface of the moon. Obviously, we are limited, in our approach to the problem, to a determination of the effects which the materials have on sunlight on reflection. One and a quarter seconds after the sun's rays leave the moon they reach the earth. We can study and measure these reflected rays by different methods and compare them with direct rays from the sun. We can also study and measure the changes produced in sun's rays on reflection by terrestrial materials, such as rocks of various kinds and other substances. These changes are not limited to the visible spectrum, but include all the radiation received through the earth's atmosphere from the ultra-violet into the infra-red. The effects produced are of two kinds: a certain amount of plane polarization is introduced and different parts of the spectrum are reflected to different degrees. Light is considered to be caused by vibrations in a special medium. These vibrations take place, in free space, at right angles to the direction of propagation. If the vibrations are limited to a single plane containing the direction of propagation and a line perpendicular thereto the light is said to be plane polarized. White light consists of vibrations of different frequencies; it can be resolved into its component parts or frequencies by the use of a spectroscope or spectrograph. The human eye is sensitive to a small part only of the range of radiation frequencies; this part is called the visible spectrum; those portions which are beyond the power of the eye to sense are called the ultra-violet and the infra-red, respectively, when the frequencies are higher or lower than the frequencies in the visible spectrum.

Thus far we have used, and are still using, four different methods for these measurements; a visual method employing a special polarization eyepiece for the measurement of the amount of plane polarization in the rays for different points on the moon's surface and at different phases of the moon; a photoelectric-cell method for the measurement both of the amount of plane polarization and of the relative spectral intensities of the rays; a thermoelement method for the same purpose; and a polarization spectrograph. These methods require special apparatus, devised or adapted to the problem in hand. The moon is an unusually favorable object for the testing of new methods and apparatus suitable for analyzing the characteristics of sunlight reflected by a planet or satellite of the solar system.

For the visual measurements a special eyepiece enables us to ascertain the percentage plane polarization in a moonbeam accurate to one fifth of one per

cent. The field of the eyepiece is a divided photometric field in which two factors, equality of illumination and exact alignment of Savart fringes, are the two criteria used in making a measurement; it is the combination of these two factors which renders the method so accurate. With the aid of this eyepiece 24 selected small areas on the moon have been studied and the amounts of plane polarization in the reflected light measured for different phases of the moon. The measurements extended over four lunations, and nearly 10,000 individual readings with the new eyepiece mounted on a six-inch refracting telescope were made, so that we now know with a fair degree of certainty the amount of plane polarization present in a beam of moonlight from any given area on the moon at any given phase. The general results are shown in Figs. 5 and 6. On an average the mountains and lighter areas reflect more light and contain approximately half as much plane polarized light as the light from the maria and other dark areas. The maximum polarization occurs at the lunar phase angles, 100° to 110° and 280° to 290°, and attains the maximum value of 16 per cent. in the case of one or two maria. The plane of vibration is commonly normal to the plane of incidence; but near full moon the polarization is negative and the plane of vibration is in the plane of incidence. At phase angles, $\pm 22°$ to 23°, the polarization is zero for practically all points on the moon's surface. It is also zero for phase angles 0° (full moon) and 180° (new moon). This negative polarization, first discovered by Lyot, attains a value roughly of one per cent. as a rule. It is an abnormal phenomenon and is probably due to diffraction and scattering. It is also observed on terrestrial materials.

Measurements of the percentage amounts of plane polarization in sunlight reflected by terrestrial materials are being made with the new eyepiece; they are not yet complete. When finished, they will enable us to group the materials according to this property and thus to ascertain with a fair degree of probability the nature of the lunar surface materials. We know from measurements made with the less accurate predecessor to this eyepiece that dark, opaque rocks and other substances polarize the light more or less completely at certain phase angles; whereas light-colored rocks and materials, into which the light can penetrate and be reflected, polarize the light relatively little, thus indicating that the lunar surface materials are of the latter type. Additional evidence that the surface materials are of the nature of volcanic ashes and pumice, high in silica, is given by the rate of cooling of the moon's surface during an eclipse. As the earth's shadow passes over the moon its surface temperature drops, in the course of an hour, from +120° C. to below –100° C., according to measurements by Pettit and Nicholson of Mt. Wilson Observatory. This signifies, as computations by Dr. Epstein of our committee show, that the lunar surface materials are exceedingly good heat insulators; in other words, they have very small heat capacity, are poor heat conductors and can not, therefore, be massive materials, like granite or limestone, but rather light substances resembling, in characteristics, pumice and volcanic ashes.

Measurements by the three other methods, photoelectric cell, thermoelement and the polarization spectrograph, are now in progress. In these three methods the special apparatus is mounted on a 20-inch reflecting telescope and the light from a given small area on the moon is received on the light-sensitive receiver. The photoelectric cell attachment consists of a special large compound Wollaston prism of quartz in a rotatable mount, a vacuum potassium

Kunz photocell of fused quartz, and the special amplifying circuit of DuBridge and Brown adapted and improved by Dr. Stebbins and employing the new electrometer tube, D–96475, of the Western Electric Company. A more refined apparatus of this type is employed by Dr. Stebbins in his work with the photoelectric cell on the stars and nebulæ. The thermoelement is of the vacuum type, made by Dr. E. Pettit, and is equipped with the rotatable compound Wollaston prism of quartz; like the photocell it is used together with ray filters to isolate certain parts of the spectrum. The thermoelement is not nearly so sensitive as the photocell, but it extends over the entire spectrum and is useful as a check on the other measurements. The polarization spectrograph is of the ultra-violet type but also serves throughout the visible spectrum. In the parallel beam between the collimator and the first prism a Wollaston prism of quartz in a sliding mount can be inserted and two spectra obtained, the one with vibrations in the plane of incidence and the second with vibrations normal thereto. Approximately 200 spectrograms of different parts of the moon were taken with this spectrograph during the past summer. The spectrograms yield information both on the percentage polarization for any given wave-length and on the relative intensities for different wave-lengths. Although not so sensitive as the photoelectric cell, the polarization spectrograph covers a much wider range of wave-lengths, through the ultra-violet into the deep red of the visible spectrum.

Program for Further Work

We plan to complete these measurements within the next two or three years; also to measure the changes in polarization of total moonlight with change in phase and for different parts of the spectrum; also the change in total intensity of moonlight with change in phase; also to obtain additional photographs of satisfactory quality to enable us to proceed with the preparation of the photographic lunar map. We are working along quite definite lines with apparatus and methods developed in detail. We shall gather data of measurement which should enable us to ascertain with fair certainty what the lunar surface materials are and how they are disposed over the surface of the moon in so far as it is visible to us. With that information available, together with a good lunar map and a knowledge of the conditions existing at the surface of the moon, we shall be in a position to attack the problem of the physiography and mode of formation of the lunar surface features.

The question arises: Why should a problem of this sort be solved? Why should a scientist give of his time and energy to their solution? These are proper questions and they should be faced. The scientific spirit of the investigator impels him to search after the truth and to do so by experiment and measurement. His interest is objective and is centered chiefly in the overcoming of difficulties incident to the pioneer work of advancing knowledge. For the most part he is the expert workman, operating through his fingers, using tools of his own design and adding his bit to the fund of knowledge. In the case of a problem like that of the moon, he does not inquire too closely into the immediate usefulness of the results obtained; his first desire and task is to devise methods and apparatus adequate for the attack. The routine measurements needed to obtain the results are a necessary step toward the solution. That these methods and devices will have

application to other problems of similar nature is to him a satisfaction; but the real incentive is the game of overcoming the difficulties inherent in the problem.

Experience has shown that scientific research work does yield returns, even when the research problem is in the field of astronomy. The several fields of science are so intimately related that advance in the one field commonly means advance in another. The practical applications of the results of science and of its method of approach have meant much to us in a physical and materialistic sense; but equally important is the training in attitude of mind toward nature, its constancy and reliability. We research workers fail in our task if we do not pass on some of the inspiration we derive from close contact with nature, its forces and factors which are quite beyond our comprehension. We glimpse these elements from afar and realize with humility how limited is our understanding of even simple things. But we do sense a goal which, if it were more generally realized, would add stability and proper placing of emphasis on the things that count and tend to bring us into accord with the principles of life which endure and have stood the test of time and human experience.

PERSIA—A LAND OF MEDIEVAL FARMING

By ALFRED HEINICKE
WALDHEIM-SAXONY, GERMANY

Years before biblical history touched hands with Persia, there was a comparatively advanced state of civilization in that exceedingly ancient country. Great wealth and never-failing romance were associated with it. Lovely women adorned with costly pearls, gallant soldiers with diamonds glittering in their swords and daggers, flash across the stage of Persia's changeful history. The wise Darius, the brilliant Cyrus, the March of the Ten Thousand detailed by Xenophon until its thrilling culmination bursts on one in the thanksgiving cry "Thalassa! Thalassa!" when the soldiers catch a glimpse of the "twinkling footed" sea, all these things remind us of a glorious past, when Persia filled a great space upon the world's stage of events. . . .

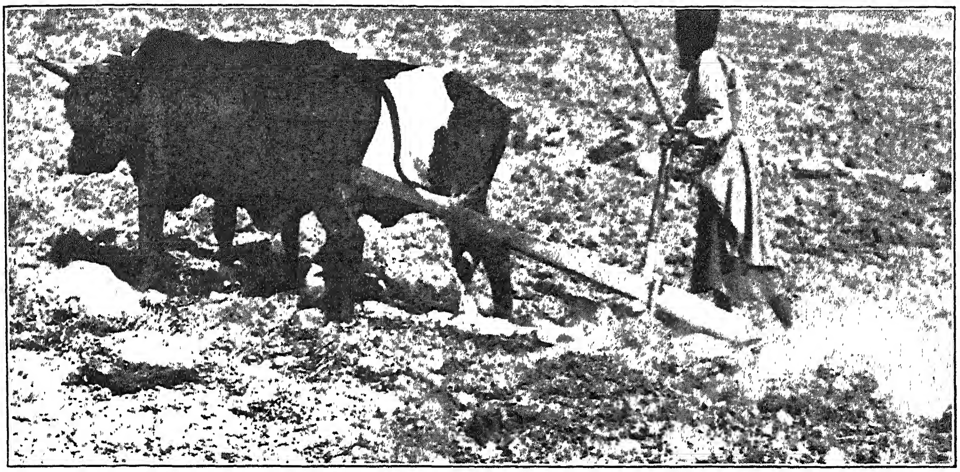
And to-day? Western civilization as yet has made little impression on the great old empire. Western progress, the modern inventions in agricultural machinery and scientific methods of cultivation have passed over this country without leaving any signs on its agriculture. The land is still tilled in much the same way as in the days of the Great Cyrus. . . . The simplest and most primitive tools and implements are employed to break up and prepare the soil. The plough, drawn by a pair of Zebus, is a very crude affair. The share, made of soft iron imported from Europe, is attached to rough wooden bars made by the village carpenter, and the plough is fastened to the heavy yoke by a chain. . . . The soil is merely scratched on the surface, for the depth to which the share penetrates depends entirely on the physical exertion of the driver, who is often merely a youth. . . .

Rolling with a Plank

As soon as the rainy season sets in, generally in November, field work begins. Only two kinds of grain are grown in Fars, the most fertile part in Southern Persia—wheat for bread, and barley for the food of the horses, donkeys and mules, although the latter is often used for food by the poorest classes. . . . When the seed has been sown, a plank five feet long by one and a half feet broad, weighted by the driver standing on it, is driven over the ground to level it, and to cover the seed so that it may not be washed out of place when the fields are flooded. If the rains are abundant, the young green blades soon show above the ground, but if the rains fail, irrigation must be resorted to. Then the few springs which exist in the Shiraz valley become worth a good deal of money. . . . Water is very scarce in Southern Persia and has to be bought by most farmers throughout the dry season from April to November. On specified days in the week each field owner gets his supply for certain hours. The fields are then flooded. To retain the water as much as possible each group of fields is divided by numbers of bolks two feet high, which confine the water. In this way the earth is thoroughly soaked. . . .

Primitive Irrigation

Where running water is not obtainable, wells are dug. From these wells, some of which are as much as sixty or a hundred feet deep, the water is drawn by horses or other animals. A rope attached to the harness runs over a wooden wheel above the well's mouth. The "bucket" consists of the skin of a sheep or goat, from the neck of which the water flows into a basin level with the ground and then through narrow channels to the growing crops. These wells can be seen and the squeaking noise of the wooden wheels heard throughout the land. Supplementing the wells as

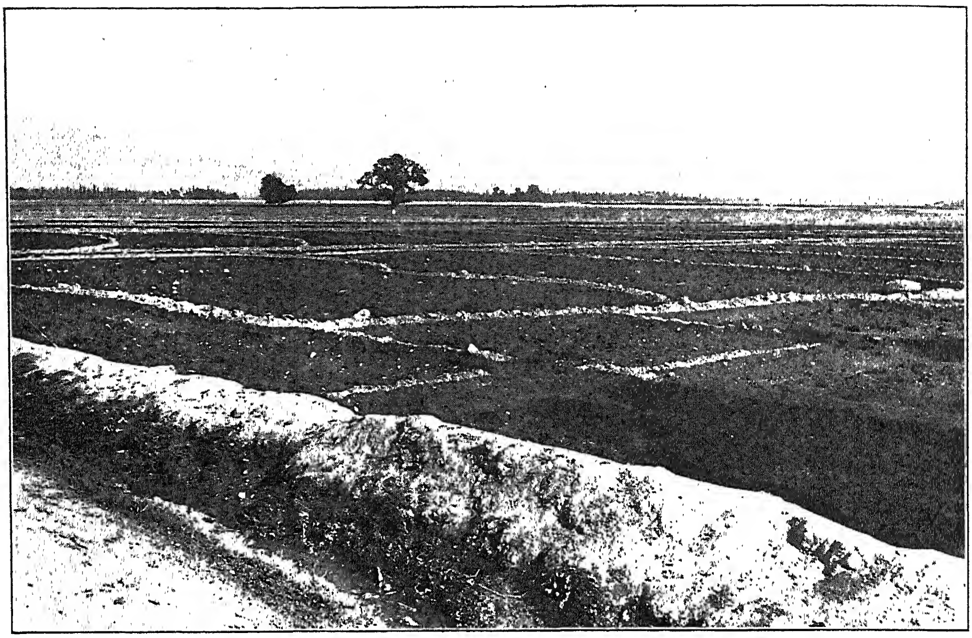


PLOUGHING IN PERSIA.

AS SOON IN NOVEMBER AS THE FIRST RAINS HAVE FALLEN, THE FARMER PLOUGHS HIS LAND WITH THE PRIMITIVE PLOUGH SHOWN IN THE PICTURE.

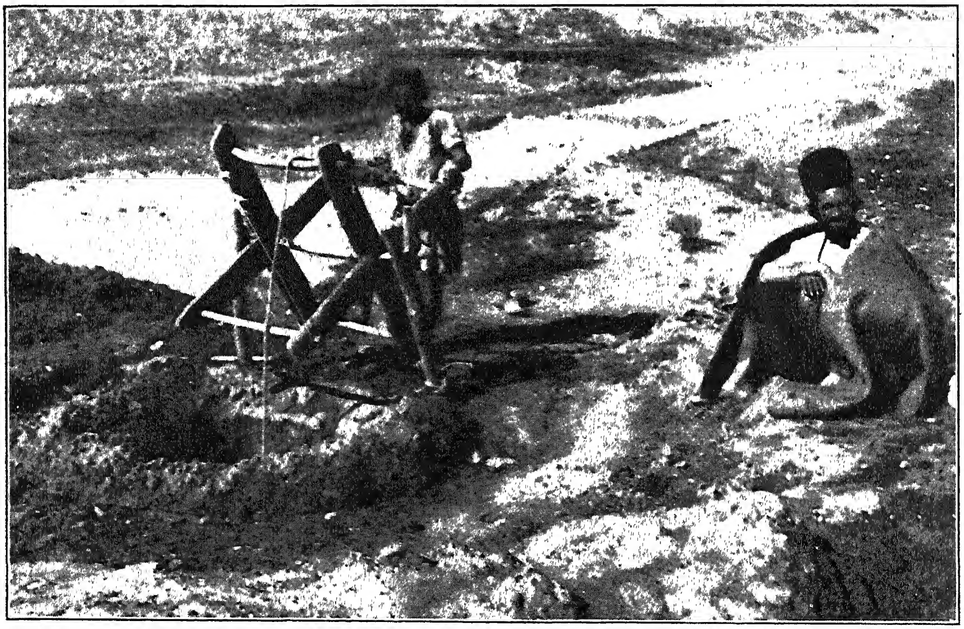
THE IRRIGATION SYSTEM.

AS SOON AS THE FIELD IS PLOUGHED THE CHANNELS FOR IRRIGATION ARE DRAWN OVER THE FIELD. AND WHEN IRRIGATED EACH PORTION IS SOAKED THOROUGHLY. THIS IS GENERALLY DONE ONCE A WEEK.



A FIELD PREPARED FOR IRRIGATION.

ALONG THE SMALL BALKS SEEN IN THE PHOTOGRAPH RUNS THE CHANNEL FOR THE WATER.



CLEANING THE AQUEDUCT.

THE WAY IN WHICH AN IRRIGATION UNDERGROUND AQUEDUCT IS CLEANED OF THE MUD COLLECTED DURING SEVERAL YEARS. A MAN IS IN THE AQUEDUCT TO SHOVEL THE MUD INTO BUCKETS. THE MAN AT THE WHEEL PULLS IT UP.

sources of irrigation water are aqueducts, very often many miles long, and running usually underground, through which the water is led from the mountains to the plains and villages. The soil thrown up in digging these passages forms mounds at the mouth of the shafts which are sunk at intervals of twenty-five or thirty yards. The digging of these canals is a special trade and the secret of their construction is guarded jealously by the men who earn their living in this manner.

The crops begin to ripen and the harvesting starts about July in the Shiraz valley, but earlier as one goes farther south. The simple sickle is the only reaping implement used all over the country. When the crop is reaped, it is not tied into sheaves, but is merely stacked up, as hay is treated in England.

Threshing Machine Uses Cow Power

When threshing time arrives the simplest of machines appears on the scene. This is a combined thresher and chaff cutter. Between two broad, wooden runners there is a pair of wooden rollers in which short, wide, blunt knife-blades are fixed. The upper part consists of four wooden uprights on which a very small board is mounted, as seat for the driver. A pair of Zebus drags this machine over the straw, which is spread flat on the ground and is cut or rather broken up by the constantly rotating knives, while the pressure of the runners separates the grain from the husks. The weight of the driver supplies the necessary pressure. It takes eight or ten days to thresh out a stack, and when this is finished, if the wind is blowing freshly the winnowing can begin. Again a very simple instrument, merely a wooden fork, is all that is used by the peasants. The monsoon, which blows in August and September over Southern Persia, plays an important part in this proceeding. The winnowers start on the weather side of the threshed stack, tossing the chopped straw into the air with their forks, the breeze blows the light chaff several yards to leeward, where it collects in a heap, while the heavy grain falls at the feet of the work-

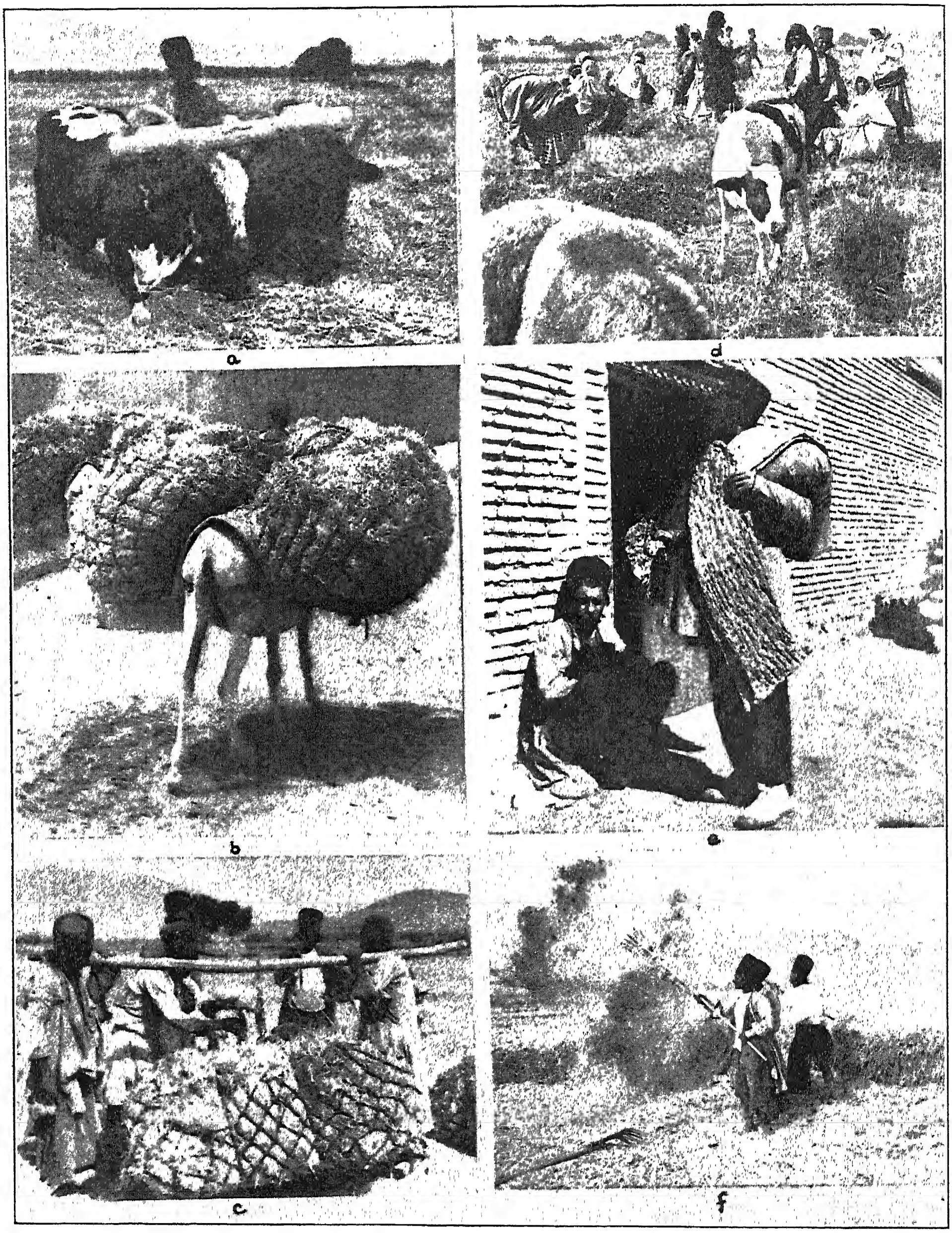
a

b

c

ON A PERSIAN FARM.

a, A WELL FOR IRRIGATION. b, CUTTING THE GRAIN WITH THE SIMPLE SICKLE. c, THE PERSIAN SLED-LIKE THRESHING MACHINE WITH THE KNIVES ON THE ROLLERS.



HARVESTING THE GRAIN.

a, THRESHING THE GRAIN. b, BRINGING IN THE CHAFF. c, WEIGHING THE CHAFF. d, WHEN THE FIELD IS FINISHED THE POOR GLEAN THE FIELD. e, THIS IS THE PANCAKE-LIKE PERSIAN BREAD. HALF-WARM IT TASTES BEST. f, WINNOWING THE THRESHED GRAIN AT THE BEGINNING.

A STACK HALF WAY THRESHED. THE DRIVER SITS ON THE MACHINE AS WEIGHT.

ers and in this rough-and-ready manner the separation of the grain from the chaff is effected.

Gleaning Still Permitted

The remaining operations of harvesting are very simple. The chaff is baled up in large specially made nets, and brought on donkeys to the villages, while the grain follows in bags on the backs of mules or horses. The poor people are now allowed to glean over the fields, sifting the dust and gathering such grain and chaff as is left. Before the grain goes to the flour mill, it is cleaned once more in a stone mortar with heavy wooden pestles, to get rid of the remaining husks.

The Persian wheat bread is sold in flat pancake-like pieces called "sangak" (from *sang,* the stone), due to the fact that it is baked in an oven with a floor of heated pebbles. As it is so thin, it is baked thoroughly and tastes best while still warm. As the poorer classes all over the south of Persia live on nothing else but bread, the harvest means everything to them, and the price of wheat is a most serious matter. . . . Bread riots break out if prices reach the famine point, and are a source of much trouble to the government. Therefore it is the aim of the new Shah Reza Khan to build several big dams to impound all the rain water which otherwise flows to waste during the wet season from November to March every year. Such plans when realized will be a great blessing for the country, since thereby a lot of waste land will be turned into fertile grain fields to feed additional thousands of people. The importance of such measures may be appreciated, since Persia has only one third of its ground under cultivation, due in many parts to the scarcity of water. Since I returned from Persia many new suggestions have been proposed to increase the water of irrigation. So far the lack of capital has prevented their realization. The word of Cyrus to Xenophon is still true: "My father's empire is so great that the people freeze to death at one end and die of thirst at the other."

SOME BOTANICAL ASPECTS OF PERISHABLE FOOD PRODUCTS

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It is not unusual to find a non-botanical individual who does not think of harvested products as actually alive and who is surprised to learn that apples and oranges are really carrying on respiration. It is also not unusual to find a botanist whose conversation would indicate that in his opinion the things of real botanical interest are confined to the great outdoors. Plant physiologies, plant pathologies and other botanical texts, even the most recent ones, have very little space given to after-harvest botanical activities, and the same is true of the courses planned for students in high school and college.

There is some justification for this situation. The harvested product does not represent the full range of botanical activities. Photosynthesis is a thing of the past and there is no longer the mooted question as to how the soil stream makes its ascent. Transpiration, however, is still an important factor, and respiration with its related metabolic activities has come to the front as the major consideration. There is no longer the interesting question as to what the product is going to become but rather the question as to how long it is going to survive. The problems are mainly those of senescence rather than youth. The metabolism has more of the destructive than the constructive.

Harvest time marks a great change not only in the plant activities but in man's attitude towards them. Prior to harvest, man resorts to every feasible means to increase the plant processes by such agencies as fertilizers, irrigation and cultivation. After harvest he looks for every possible means of slowing down the natural plant processes. His interest is in finding the best manner of putting on the brakes, and in seeing how tightly they can be set without wrecking the machine.

In spite of the more limited range of activities many interesting problems are involved in the botany of the harvested product and many that have an important bearing on our every-day life—on what we eat, how it tastes and what we pay for it. These problems have been intensified by the fact that in present-day living the producer and consumer are usually separate parties and often long distances apart. The percentage of food that is consumed by the families that produce it has become extremely small. Even the farmer draws heavily on the local market for a great variety of food materials, and the stacks of fruits and vegetables in the receiving markets of our large cities are an almost unbelievable sight. To give the actual quantity in bushels or even in carlots would run into figures too large to be readily comprehended. All this volume of material is carrying on botanical activities from the time it is harvested till the time it passes into consumption. The methods of handling should be based on botanical laws. In actual practise these laws are not infrequently violated and the consumer foots the bill, either in the price he pays or in the poor quality of food he receives.

For one who feels inclined to study the night life of a large city, the New York fruit and vegetable piers offer a good place to start. There is plenty

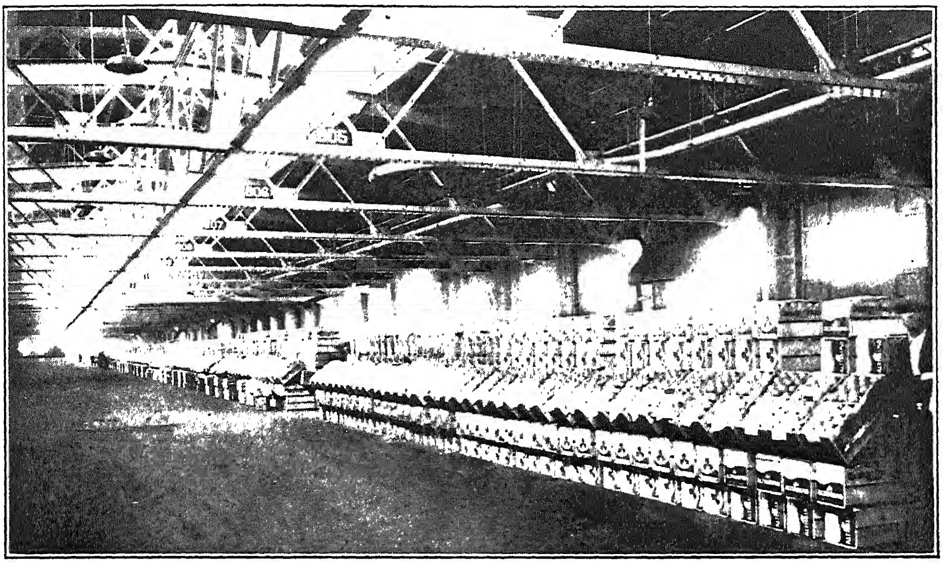

FIG. 1. NEW YORK PIER,
SHOWING PART OF THE DAILY SUPPLY OF CITRUS.

doing all night through and well on into the next day (Fig. 1).

After-harvest botany is one of the newer and younger fields of botanical activity confined largely to the present century and having its real beginning in the Paris Exposition of 1900. It has not been taken up as a fad but rather as a necessity, as a result of our changed methods of living. Research in the field has been confined almost entirely to institutions supported by public funds; outstanding among these have been the U. S. Department of Agriculture and some half dozen state experiment stations. Older institutions like Harvard and Yale have contributed little. Since the world war England has come into the field in a most aggressive manner and with excellent results. The world war apparently aroused greater interest in the maintenance of a satisfactory food supply. South Africa, Australia and New Zealand have followed in a minor way, and the latest convert is Italy.

A recent Italian publication, "Annali della Sperimentazione Agraria," contains a half dozen or more articles on transportation and storage of fruits, vegetables and flowers, illustrated with a large number of excellent colored plates. This is a new field for Italy, and judging by the number of workers reporting and by the elaborateness of the publications, it is one in which she plans to take an active part.

The reason for this new activity in Italy lies in the fact that the orchard areas that are coming into production are certain to produce a surplus, for which distant markets must be developed. This is not unlike the demands that have arisen in the United States. The call for help has usually come from the producers who were looking for a market, and if a better method of handling a product has been discovered, the value of the discovery has usually been measured in terms of the benefit to the particular group of producers. The fact seems to be overlooked that improving the shipping or marketing conditions for one group of producers sometimes

drives others to the wall and that the greatest importance of the accomplishment lies in the benefits given the consumers. That a small group of producers has found a more profitable market is actually a small item compared with the fact that many millions of people may have been supplied with a cheaper, better balanced or more healthful diet.

Every movement has its pioneers and leaders around whom growth and progress have centered, and after-harvest botany is no exception. Much of the progress in this field during the last 35 years, during practically its entire period of development, has centered around one individual, Dr. W. A. Taylor, chief of the Bureau of Plant Industry. He has been continuously outstanding both as pioneer and leader. An already recognized authority on after-harvest conditions, it was his responsibility to see that American fruit was kept continuously on display in good condition at the Paris Exposition of 1900. Selected lots of apples of the leading commercial varieties from 17

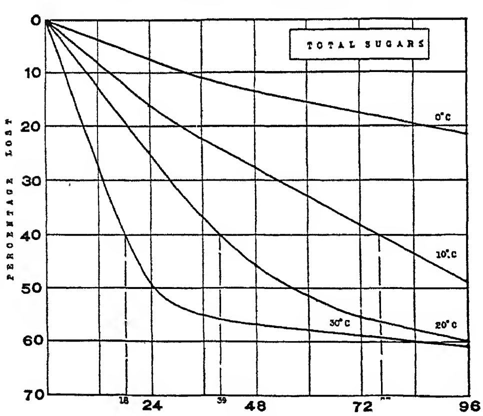

FIG. 2. DEPLETION OF TOTAL SUGARS IN GREEN SWEET CORN DURING CONSECUTIVE 24-HOUR PERIODS OF STORAGE AT DIFFERENT TEMPERATURES. THE ORDINATES ARE GIVEN BY THE NUMBERS ON THE LEFT OF THE FIGURE AND REPRESENT THE LOSS OF SUGAR EXPRESSED AS PERCENTAGES OF THE INITIAL SUGAR, WHICH WAS 5.91 PER CENT., WET WEIGHT. APPLEMAN AND ARTHUR.

different states were assembled in cold storage in the fall of 1899 and later transported overseas under refrigeration for exhibition purposes. It was Dr. Taylor's observations on the diseases and behavior of this fruit that resulted in the inauguration in the Bureau of Plant Industry of the U. S. Department of Agriculture of systematic experimental investigation of the effect of environmental conditions upon fruits and vegetables in storage and transit.

In the Yearbook of the U. S. Department of Agriculture of 1900 Dr. Taylor has an article on "The Influence of Refrigeration on the Fruit Industry," a fascinating report of early patents and devices for refrigerator cars and cold storage rooms, with notes on the successes and failures in the control of diseases. Papers followed reporting difficulties in fruit handling, such as the spoilage of stone fruits in the top layers of the car and the development of scald on apples in storage, and then a series of papers by others, but all mentioning his cooperation and direction and all apparently initiated by his grasp of the needs of the industry. In this series came "The Apple in Cold Storage" and "Cold Storage with Special Reference to the Pear and Peach," by Powell and Fulton, of the Bureau of Plant Industry, both publications in 1903, and "Studies on Apples" by Bigelow, Gore and Howard, of the Bureau of Chemistry, in 1905. These papers marked practically the first real attempt to bring scientific investigation to the service of the public in the study of the after-harvest behavior of perishable food products and are outstanding as initiating a new botanical development.

In the years that have followed Dr. Taylor has continued his sympathetic and stimulating influence in this field of investigation, and as chief of the Bureau of Plant Industry has been largely responsible for its interpretation to the

public. The customs and practises that prevail in shipment and storage are fundamentally based on his interpretation of botanical principles as related to divided public responsibility. It is interesting to contemplate the benefits that have come to our millions of people through the loyalty and wisdom of his service.

In Powell and Fulton's reports of 1903 and in Fulton's report on the cold storage of small fruits in 1908 no literature was mentioned. The writers were in the fortunate position of having no literature that needed to be mentioned. Prior to the present century the French had contributed most to the study of the after-harvest behavior of food products, yet practically nothing that could serve as a basis for modern methods of handling them. Such studies as had been made on respiration and sugar content were confined largely to the period of ripening and were apparently stimulated by interest in the wine industry.

Bigelow, Gore and Howard in their "Studies on Apples" gave us the first fundamental investigation of after-harvest processes under cold-storage conditions, and compared the rate of respiration and the disappearance of sugar at the two temperatures of 32° and 60° F.

Morse, biochemist at the New Hampshire Experiment Station, gave a brief report in 1908, calling attention to the fact that the rate of respiration in apples was approximately doubled for each 18° F. rise in temperature. Gore followed in 1911 with his "Studies on Fruit Respiration," carried out in cooperation with the Bureau of Plant Industry—a very comprehensive report on the subject with a complete range of temperatures. He estimated that the rate of respiration was increased 2.4 times for each 18° F. rise in temperature, and found that oranges and lemons respired about half as fast as apples,

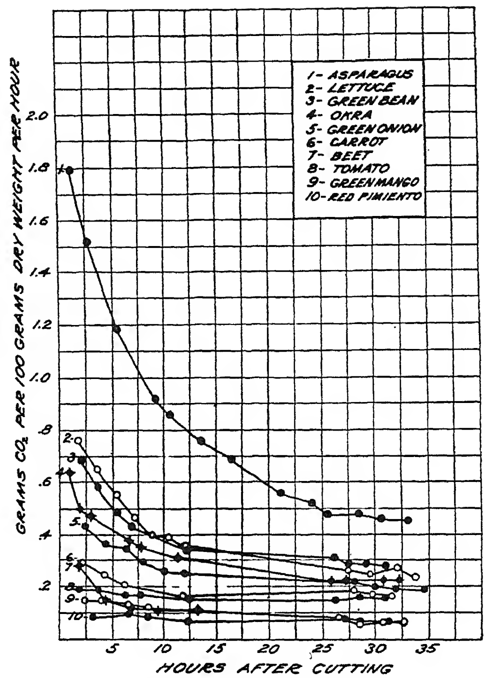

Fig. 3. Curves showing decline in respiration rate of fresh vegetables during the a constant temperature of 30° C. (± 0.5). first 30 hours after cutting, when held at Benoy.

peaches and huckleberries about twice as fast and berries in general about five times as fast. These studies on respiration stand as a foundation and background for a great deal that has followed. It would be interesting to make a compilation of the publications that include Gore's work in their references.

From 1911 to the close of the world war there were few contributions to after-harvest botany. During a part of the period all efforts were centered on winning the war.

During this 7-year period Appleman published on the storage behavior of potatoes, showing that sugar accumulated at the expense of starch when the temperature fell below 38° but that this sugar could be converted back into starch by removing the potatoes to a higher temperature. He found that the

rate of respiration was accelerated by a rise in temperature and also by accumulated sugar. Hasselbring and Hawkins published on the "Respiration and Carbohydrate Transformations in Sweet Potatoes," finding a response to temperature similar to that which has been pointed out for fruits.

With the close of the world war we entered a new era in after-harvest botany. From 1918 to the present date publications have appeared thick and fast, covering various phases of diverse crops and all looking to the determination of what is actually going on in the harvested product.

Following the line of respiration and carbohydrate changes, sweet corn had first attention. In 1919 Appleman and Arthur pointed out the rapid depletion of sugar in the first 24 hours after harvest; six times as great at 86° F. as at 32° F. and three times as great at 68° as at 32° (Fig. 2). A publication the previous year by Appleman had shown that most of this loss in sugar was due to the conversion to other carbohydrates rather than to consumption in respiration. It is easy to see that after 24 hours at a high temperature sweet corn no longer deserves to be called sweet and, unfortunately, succulence and freshness disappear with the sweetness. Stevens and Higgins also published on sweet corn in 1919 and with results in agreement with those of Appleman and Arthur.

The interest in peas and beans lagged some 12 years behind that in corn, but several comprehensive publications have appeared in the past 3 years. The data recently reported by Kertesz of Geneva, N. Y., showed that with market ripe shelled peas nearly 40 per cent. and with immature peas more than 40 per cent. of the sugar was lost in the first 6 hours after harvest, if held at 77° F. The sugar was not converted into starch, as sometimes supposed, but apparently used in respiration. The loss in flavor and quality was greater than the loss in sugar. Blanching and holding at cold storage temperature greatly delayed the deterioration.

Bisson and Jones, of California, have compared the loss of sucrose in shelled and unshelled peas when held at 77° F. In 24 hours the shelled peas had lost considerably more than 50 per cent. of their sucrose whereas the unshelled ones had lost less than 30 per cent. The starch increased far more rapidly in the shelled than in the unshelled peas.

Carolus, of Virginia, has given us a similar study on green lima beans. He found that the loss of sugar was greater in the shelled than in the unshelled product, but his big contrast was between summer and cold storage temperatures; with the shelled beans showing a 69 per cent. loss in 24 hours at summer temperature and a 38 per cent. loss in cold storage. The percentage of other constituents was also reported, but the sugar content is probably the best index of quality.

There is nothing in these various reports to encourage the consumer to buy shelled peas and beans and much to justify him in demanding a product that had been as free as possible from exposure to high temperature.

With peas, corn and beans the rate of deterioration has been found to decrease with longer periods of storage. This seems to be even more strikingly true of asparagus as brought out in the work of Marjorie Benoy (Fig. 3). Note the rapid fall in the rate of respiration in the first 10 hours. With lettuce, green beans, okra and carrots the decrease is also decided.

It should also be noted that asparagus stands out preeminent in its rate of respiration after cutting. Morse, biochemist of New England, was the first to call attention to the rapid loss of sugar and quality in asparagus and the favorable

effect of low temperature. Bisson, Jones and Robbins found that at 77° F. asparagus lost 18 per cent. of reducing substances (chiefly sugars) in the first 24 hours, whereas at 33° there was no loss. The loss in sugar was thought to be partly due to transformation into cell wall material, thus contributing to the toughening of texture.

Hopkins extended Appleman's work on the potato, showing that respiration was actually greater at 32° than at 37° at lower temperatures. Upon removal from 32° to 60° respiration at first increased, and then decreased to about the normal 60° rate.

Parsnips were studied fairly early in the post-war period by Boswell of Maryland. Storage at 34° greatly increased the sugar content and improved the quality as compared with cellar storage or leaving undug. Two weeks at 34° gave a quality equivalent to that obtained in the field in two months.

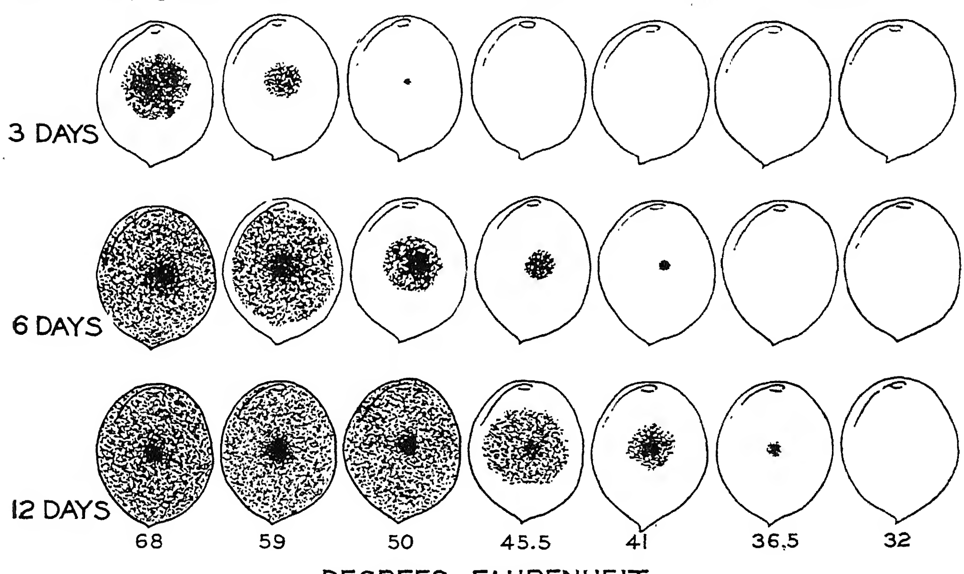

FIG. 4. EFFECT OF TEMPERATURE ON THE DEVELOPMENT OF BROWN ROT ON PEACHES.

THE SHADED AREAS INDICATE THE EXTENT OF DECAY. THE UPPER SERIES SHOWS THE SIZE OF THE ROTS AT THE VARIOUS TEMPERATURES AFTER 3 DAYS, THE SECOND SERIES AFTER 6 DAYS, AND THE THIRD SERIES AFTER 12 DAYS.

to 40° F. The higher respiration at the lower temperatures, in violation of the usual law of plant activities, was attributed to the increased concentration of sugar at those temperatures.

Wright has just published a very complete report on the physiological behavior of potatoes in storage and after storage, confirming the results of Appleman and Hopkins and showing that there is a slight increase in sugar even at 40° F. and a much greater increase

Hasselbring in 1927 reported on the behavior of carrots in storage, showing that at 39° to 40° F. they lost 43 per cent. of their sucrose in 10 weeks and at 32° to 35° F. 28 per cent. in a similar period. He found that flavor disappeared with loss of sugar content and emphasized the importance of low temperature and early consumption.

The apple and related pome fruits in keeping with their commercial importance have remained in the lead in the

after-harvest studies. The apple has been an article of export from the United States for nearly two centuries and during much of that period was practically the only export product in the perishable fruit and vegetable group. The New England export shipments of ice were accompanied by shipments of apples on a large scale, and this export trade in ice extended at one time even to India and China. The early cold storage plants were largely for apple storage, and the apple still holds the lead in the volume of export and in the volume in storage.

Magness, Diehl, Haller, Pentzer, Burroughs and others have a series of reports on the after-harvest behavior of apples, correlating the rate of softening with the rate of respiration, determining the internal atmosphere under different storage conditions and studying the effects of harvesting at different maturities. Burroughs found that the rate of respiration sometimes increased during storage.

Harding made a detailed study of this increase in respiration rate and showed the serious results of moving apples from a higher to lower temperature when at their maximum activity.

Magness and Ballard had previously shown that the respiration rate of Bartlett pears is far from constant. At 59° F. they found an acceleration from the time the fruit was picked until it was soft, yellow ripe, the highest rate being seven times the initial rate. At 37° there was no acceleration within a month and at 32° none within four months. They found that the catalase activity of the pears first increased and then decreased without a close parallelism with respiration.

Catalase has sometimes been considered a respiratory enzyme, but both Drain and Harding have failed to find any correlation between catalase activity and respiration of apples when held at a low temperature. Harding found a possible correlation at 50° F.

Carre found that there was a decrease in protopectin of apples in storage and Appleman found a similar decrease in peaches. Haller has recently reported studies showing that the softening of apples in storage is apparently due to the conversion of insoluble pectic substances, principally protopectin, into soluble form. The rate of this conversion at different temperatures was found to be in proportion to the rate of softening.

Olney found that in bananas the rate of respiration increased rapidly at the beginning of ripening and fell off gradually. Fruit held at 53° F. or lower had a relatively lower rate of respiration but failed to ripen normally.

Gerhart gave a complete report on strawberry respiration, estimating the amount of oxygen required per carload and the amount of heat produced.

Haller, Harding, Lutz and Rose have a recent report on the respiration of peaches, strawberries, lemons, oranges and grapefruit, giving special attention to the sugar and acid consumed and to the heat produced in respiration.

Both American and English investigators have emphasized the importance of parasitic and physiological diseases as confusing factors in the study of respiration and serious limiting factors in the storage life of the product. In the past sixteen years there has been a long list of publications on the parasitic organisms concerned, with data as to manner of infection, temperature response, means of control and losses involved. Eustace, Schneider-Orelli, Edgerton and Miss Ames had reported on the temperature response of a few decay organisms prior to this period.

Brooks and Cooley reported on the temperature responses of apple rot fungi in 1917. Blue mold was found to be the most serious decay organism of

stored apples. Its most rapid development occurred at about 68° to 70°, with practically none at a summer temperature of 86°, none in two weeks at 50° and none in six weeks at 32°, yet the fungus making a rapid advance at low temperatures when once established. Temperature studies were reported on seven other common decay organisms of the apple.

These same authors published later on the temperature responses of peach rot fungi (Fig. 4) and used the temperature data reported for the interpretation of later shipping tests. In a shipping period of 3 to 4 days the temperature in the top of the car was found to have about 2.5 times as great growth-producing value for peach brown rot as that in the bottom of the car.

Stevens and Wilcox gave a detailed report on the Rhizopus and Botrytis rots of strawberries as affected by temperature, humidity and other transportation and storage conditions.

Fawcett has reported temperature studies on *Phomopsis citri* and *Diplodia natalensis,* the two organisms responsible for stem end rot of citrus. Both fungi were held in check by a temperature of 6° C., 42.8° F.

Fulton and Winston and Barger and Hawkins have found that blue mold of citrus can be greatly reduced by washes containing borax or other antiseptics, and Winston has recently shown the importance of applying the treatment as soon as possible after the fruit is picked.

The most comprehensive study of a group of decay organisms that has yet been made is that in connection with sweet potato storage. It includes a series of ten or more fundamental articles, mostly by Harter and Weimer, but later ones by Lauritzen, and reports a study of the decay organisms, their respiration, their enzymes, their effect upon the respiration and carbohydrate changes in the host and the response of the fungi and the host to temperature and humidity. *Rhizopus nigricans,* the most serious rot organism, was found to be a relatively low temperature Rhizopus, although having an optimum well above 70° and a minimum near 50° F. *Rhizopus tritici* was found to produce a powerful pectinase enzyme capable of affecting complete maceration of raw potato disks.

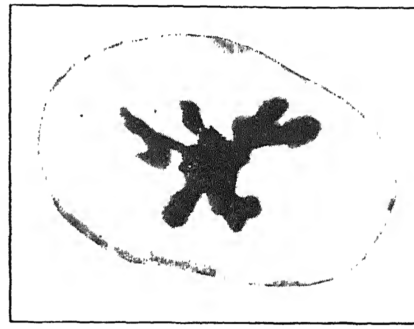

FIG. 5. BLACKHEART OF POTATOES CAUSED BY EXCLUSION OF THE AIR. STEWART AND MIX.

With high humidity and high temperature sweet potato wounds were corked over in 4 to 6 days, thus furnishing protection from fungous attack. With a humidity of 72 to 84 per cent. there was nearly 100 per cent. of infection with Rhizopus, whereas with a humidity of 94 to 98 per cent. infection was largely prevented. This is in violation of the usual laws in regard to infection, and the exception to the rule is due to the host response. The most rapid healing was at about 90° F., but cork formation occurred at as low temperature as 67.1°.

The effect of temperature and humidity upon suberization and wound-periderm formation has been followed in detail by Artschwager and Starrett.

Lauritzen found that holding sweet potatoes at temperatures below 48° F. for as long as 15 days resulted in increased susceptibility to decay.

Weiss, Lauritzen and Brierly have recently reported on the relation of tem-

perature and humidity to suberization and wound-periderm formation in the Irish potato, and Smith of Cornell has a publication covering the same subject. Wound periderm formation that required 3 or 4 days at 70° F. required more than 8 days at 50° F. Humidity was not ordinarily a limiting factor.

Lauritzen has recently published on storage and transit diseases of carrots, peppers and beans, and Tompkins and Pack on the storage decay of sugar beets.

In the fungous diseases of stored products it can be generally assumed that lowering the temperature will decrease the activity, but the work of Berry and Diehl shows that in the freezing preservation of fruits in sealed packages a storage temperature of 15° F. results in a much greater kill of microorganisms than a temperature of −5° F. However, the greater kill at the higher temperature is attributed to the greater accumulation of carbon dioxide.

The field of physiological diseases has received even more attention than that of the parasitic diseases, especially from foreign investigators. In some respects it is more difficult and controversial and perhaps for that reason a more enticing field. In contrast with diseases that are due to fungi many of the physiological diseases are produced only at low temperatures.

Potato blackheart is one of the diseases that received early attention (Fig. 5). When potatoes were held in storage or shipped in large volume the interior of the potato was later found to have turned black. Studies on the cause were in progress prior to the post-war period we have been considering. In 1915, Bartholomew reported the trouble to be due to holding the potatoes at high temperatures, such as 100° F., or above, and considered that the real cause was probably a lack of oxygen in the tissues. Stewart and Mix followed with a report in 1917, giving definite proof that the disease was due to a lack of oxygen and not to an accumulation of carbon dioxide, and showed that by means of a reduced oxygen supply and prolonged exposure, the disease could be produced at temperatures as low as 35.6° F. Bennett and Bartholomew reported a very complete study in 1924, confirming the work of Stewart and Mix and showing that, while in general longer periods of exposure were required at low than at high temperatures, the injury could be produced more quickly at a temperature of 32° than at 41°, apparently because of the increased sugar content and resulting higher rate of respiration below 41°.

But the apple is in the lead in the variety of its physiological storage troubles and outstandingly in the lead in the literature devoted to them.

The condition of fruit at the time of harvest has been repeatedly emphasized as modifying its later storage behavior. Various Plant Industry workers have pointed out the importance of full maturity in the prevention of apple scald. Brooks, Fisher and Harley found that water core of apples was greatly increased by over-maturity and high temperature, but that mild forms of the disease were likely to disappear in storage. They reported that the occurrence of bitter pit in storage was much worse on fruit that was forced late in the season and worse on early-picked fruit than on late-picked. Carne, of Australia, has recently reported that the storage development of this disease is almost entirely determined by maturity.

The difficulties in regard to apple scald in a rapidly expanding cold storage industry was apparently an important factor in initiating the early studies of Powell, Fulton and Gore. It was suspected that low temperature was the cause of scald, but Powell and Fulton showed that more scald developed at 36°

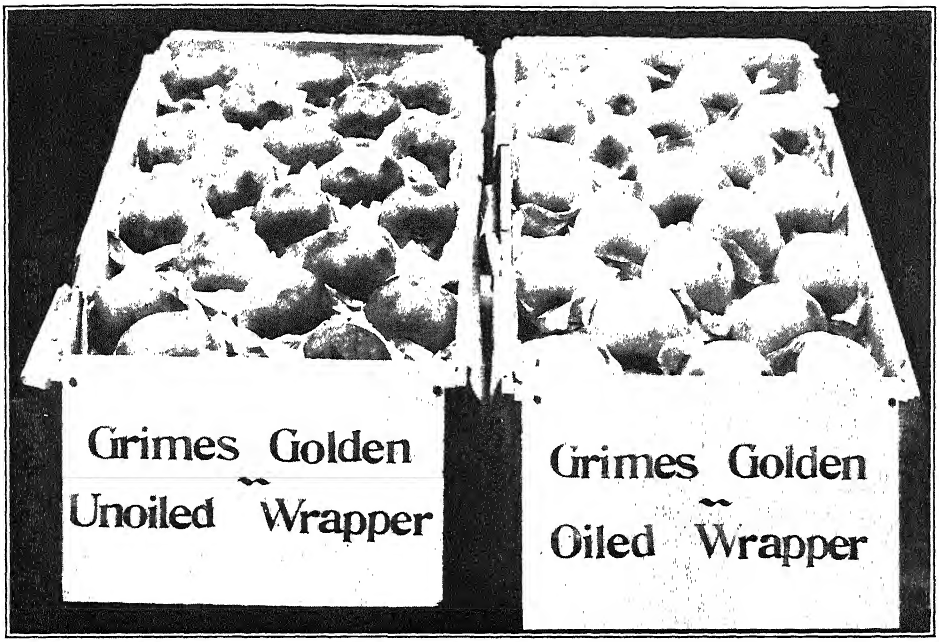

FIG. 6. GRIMES GOLDEN APPLES AFTER STORAGE, SHOWING THE CONTROL OF SCALD WITH OILED WRAPPERS.

than at 32°. Storage houses continued to receive much of the blame for scald in spite of the fact that later studies emphasized the importance of maturity in the fruit and the benefits from immediate as compared with delayed storage.

Following the world war, Plant Industry workers published a series of articles showing that scald responded to temperature in accordance with other plant activities and increased in seriousness or at least in rapidity of development from 32° up to 70° or 75°. They found it was decreased rather than increased by an accumulation of carbon dioxide, that it was not due to a lack of oxygen and not greatly influenced by humidity, yet could be prevented by aeration or by packing the fruit in oiled wrappers or shredded oiled paper (Fig. 6). This raised the question as to what harmful substance the apples could be producing that could be carried away by air currents or eliminated by the presence of oil. There was no information in this field, and the problem was taken to Power and Chesnut, of the Bureau of Chemistry. Dr. Power was a world authority on odorous plant products. They started a study on the odorous constituents of the apple and found them to consist of various esters and in addition a considerable proportion of acetaldehyde, which they suggested might be a factor in the production of apple scald. Acetaldehyde was known to be extremely irritating to human respiration and seemed to be just the thing to cause trouble in the plant metabolism, but it has proved a difficult culprit to catch in the act. In the last 10 or 12 years it has been chased up one alley and down another but never quite completely proven guilty.

Harley and Fisher found a close correlation between the development of scald and breakdown in pears and the accumulation of acetaldehyde in the tis-

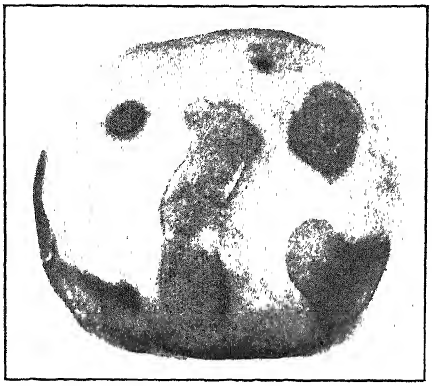

FIG. 7. SOFT SCALD ON JONATHAN APPLE.

sue. Thomas in England concluded that the accumulation of acetaldehyde in pear tissue was the result of pear breakdown rather than the cause. He emphasized the importance of the oxygen-carbon dioxide ratio as a determining factor in the occurrence of acetaldehyde and alcohol in the fruit tissues. Gerhardt and Ezell have recently found evidence that an increase in the alcohol and acetaldehyde content of pear tissue may be taken as an indicator of objectionable physiological conditions that will soon follow with continued cold storage. Various studies on acetaldehyde and on alcohol acetaldehyde ratios are in progress in England, America, Japan, Italy and Australia. Some English investigators are pointing out the dangers of acetaldehyde, while others are suggesting that its introduction into the storage air may be a possible means of controlling decay.

Nelson, of Michigan, has recently published on suboxidation and low temperature diseases of various fruits and vegetables.

Internal browning is a physiological storage disease of the apple particularly common on the Yellow Newtown of the Pajaro Valley, California. It has been shown by Ballard, Magness and Hawkins, and by Overholser, Winkler and Jacob that the disease can be largely prevented by holding the fruit at 38° to 40° instead of at 32°. The latter group of workers found that the disease could be greatly reduced by ventilation.

Soft scald is a sporadic physiological disease of apples, producing most peculiar patterns and formerly classed as frost injury (Fig. 7). The disease has been studied by Magness and Burroughs; Brooks, Cooley and Fisher; Fisher and Harley; Plagge and Maney; and by various workers in England, New Zealand and Australia. It is recognized as a low temperature disease largely prevented by storing at 35° to 38° or above and as decreased by ventilation and due to a lack of oxygen; yet very curiously can be greatly decreased by short-period exposures to carbon dioxide or to high temperatures before placing in storage.

Soggy breakdown is a companion disease to soft scald and due to similar causes. Plagge, Maney and Harding have studied the disease, also English workers.

The storage life of oranges and grapefruit is limited by the development of a pitting of the peel (Fig. 8). The disease is much worse at 36° and 40° than at 32° and storage at 45° to 50° or at a higher temperature almost entirely

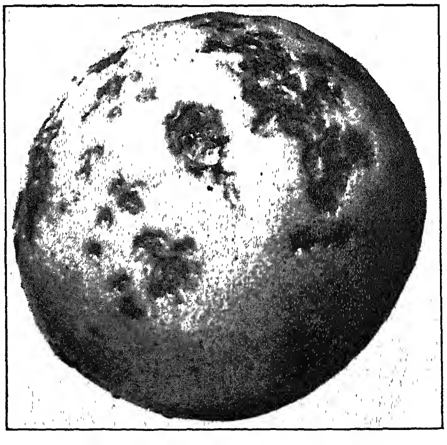

FIG. 8. PITTING OF GRAPEFRUIT.

prevents the trouble. These higher temperatures, however, may result in serious decay.

The work that has been done on these different physiological diseases has given us more or less satisfactory remedies, but the real cause is still to be found.

What is happening in grapefruit at 40° but not at 50° and what in apples at 32° but not at 38°? These are most interesting questions, but the answer is not yet in sight. A complete solution of the problems might bring about great changes in storage practises. The functional and old-age diseases of fruits and vegetables are far from being well understood. In this they have a parallel in the functional and old-age diseases of the human race.

Many attempts have been made in recent studies to obtain a better index of keeping quality. There is a long list of American publications on the effect of nitrate fertilizer on keeping quality. Archbold, of England, finds that high nitrogen value and low acidity in apples is associated with high rate of respiration. Plagge and Gerhardt, of Iowa, found that the greater the acid loss in apples the better the keeping quality. Dutoit and Reyneke, of South Africa, think they have the secret of keeping quality in a high ratio of active acid to total acid. Various writers emphasize the importance of acid in the respiratory metabolism of the fruit.

The English investigators have taken the lead of late in the study of physiological diseases and in the study of storage atmospheres in general. They not only have done excellent work and a great deal of it but they keep the public advised as to what they are doing. Our own press has frequent quotations from the English in regard to discoveries that in some instances should be largely credited to American investigators, yet the publicity has come from England and the English receive the whole credit in the minds of the public.

Here is a much-quoted statement abbreviated from the presidential address of Sir William Hardy before the British Association of Refrigeration: "A stream of air which has passed over apples contains subtle emanations which cause potatoes not to sprout or to produce misshapen dwarf sprouts and cause bananas and unripe apples to ripen more rapidly. Only elderly apples give off these emanations." The discoverer of these relationships was O. H. Elmer, a plant pathologist in Kansas, and his results were published in *Science* in 1932, but it was left to Hardy in England to use the information in a manner to attract the attention of the public to the scientific work in progress.

The English investigations after the war were first directed to a study of brown heart of apples. The Australian shipments often arrived in England with a high percentage of this trouble. It was found to be due to the high percentage of carbon dioxide that developed in the hold of the ship as a result of slow cooling. A remedy was found in better ventilation and more rapid cooling.

They followed with elaborate tests as to just the percentage of carbon dioxide the apples would stand at different temperatures, and the results of their investigations are now in practical application. According to *Food Manufacture* of London, nearly one fifth of the apples in England are now held in gas storage with the prospect that this method of storage is to be rapidly extended. With Branley's Seedling apples the best results have been obtained at about 41° F. with 10 to 15 per cent. carbon dioxide and 10 per cent. of oxygen in the atmosphere. The results under these conditions were one and one half times better than in ordinary cold storage at 34°. In later tests with Lane's Prince Albert apples better results have been obtained with a storage

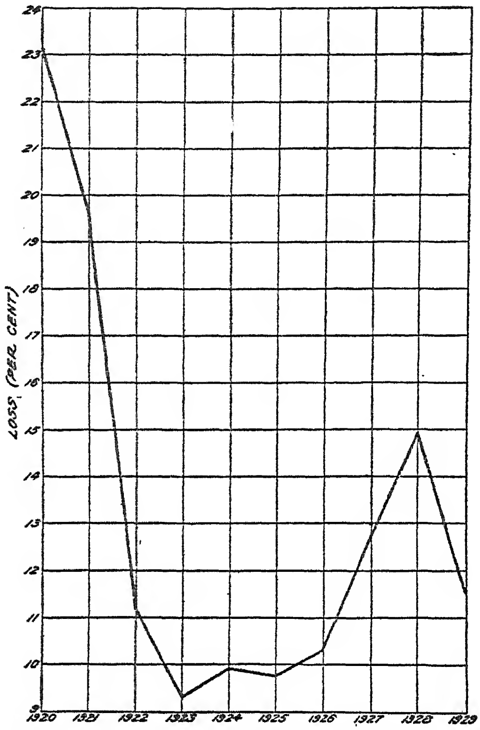

Fig. 9. Estimated losses from storage rots of sweet potatoes in the United States, 1920–1929. Stevens.

atmosphere containing but 5 per cent. of carbon dioxide and 2.5 per cent. of oxygen.

The idea of gas storage is old. Berard, a Frenchman, reported gas storage experiments more than a century ago. The Reverend Benj. M. Nyce, of Decatur, Ind., who in 1856 received a patent on his ice storage house and offers of large sums in royalties, abandoned the idea of ventilation and endeavored to accumulate atmosphere of carbon dioxide in the storage room. Gore found that carbon dioxide could be used to ripen persimmons and remove their astringent taste. In 1913 Hill, of Cornell University, published on the respiration of fruits in various gases and pointed out the danger of lack of ventilation in storage. These dangers have been further emphasized by later studies, yet the idea of gas storage has often expressed itself in rather wild schemes, one of the wildest of which was the recent citrus experiment at Howey-in-the Hills, Fla. Each of three large metal tanks was filled with three carloads of citrus fruit, sealed, the air partially or entirely displaced by other gases and the tanks left for months in the hot sun with the expectation that the fruit would be preserved in its fresh condition. The line of reasoning seemed to be that if the fruit could not get air it could not spoil. It must have got some air.

Gas storage of the English type does not seem likely to become popular in this country, at least in the near future. It does not fit well into our established customs. We do have gas storage in a mild form in the wrappers and in the waxes that are used on some of our fruits. It has been shown that these bring about an increase in the carbon dioxide and a decrease in the oxygen content of the internal atmosphere of the fruit.

Some attention has been given recently to the possibility of short-period gas storage as a preventive for the deterioration and losses that result from failure to secure rapid cooling of the harvested product. It has been found that placing a few hundred pounds of solid carbon dioxide in the car of freshly loaded fruit will result in sufficient carbon dioxide gas to check both ripening and decay to a degree that is difficult to secure with refrigeration alone, and that with conservative use of the treatment as a supplement to the usual refrigeration, no injury to the product need result. Miller has found that treatments of this character tend to preserve the sweetness and freshness of corn and peas.

Thornton has shown that exposure to carbon dioxide in the presence of oxy-

gen results in a reduction in the acidity of the plant tissue, and with some products in a marked increase in the rate of respiration and with others in a marked decrease.

Recent literature contains studies on the effect of ethylene upon sugar changes and rate of respiration when used as a coloring or ripening agent; studies on the effect of freezing upon respiration and catalase activity; studies on the changes in the waxlike coating of apples during storage; studies on the composition and physiology of various products in relation to satisfactory canning and freezing procedure; and papers dealing with various other phases of after-harvest botany that can not be followed in detail at this time.

In a presidential address before the Washington Botanical Society 20 years ago Dr. W. W. Stockberger[1] discussed the subject: "The Social Obligations of the Botanist." The burden of his talk was to the effect that the .botanist's efforts should not be dominated solely by his interest in plant life but rather by his desire to make botany of service to mankind; that he must not overlook his obligation to return value to society in keeping with and surpassing the support he was receiving from the public.

Measured by this standard, after-harvest botany can give a good account of itself in the time that has elapsed since the above address. The business of supplying perishable food products to our millions of people rests upon an entirely different foundation to-day than it did 20 or even 15 years ago. It is true that it has long been known that apples keep better in a cool cellar than in a warm one and that certain rule of thumb methods should be followed in the handling of various food products. This type of information may have been fairly satisfactory for handling farm products for home consumption, but it formed no reliable foundation for the new era of mechanical refrigeration, long distance shipments and divided responsibility. The question is no longer as to whether the product should be cooled but that of how cold, how quickly cooled and how much ventilation, and if spoilage occurs who was to blame and what the significance of this or that harvesting, shipping or storage condition. Such questions can only be answered by scientific study of the various factors involved, and in the absence of reliable information the problems are likely to be settled by costly court procedure with the consumer ultimately paying for the cost of the settlement as well as for the loss of the food. When the laws underlying a trouble have been discovered so that responsibility can be definitely placed the trouble is likely to be largely eliminated.

Here is a figure from data compiled by N. E. Stevens, showing the effect upon sweet potato storage of the research work previously outlined (Fig. 9). Note the precipitous drop in stor-

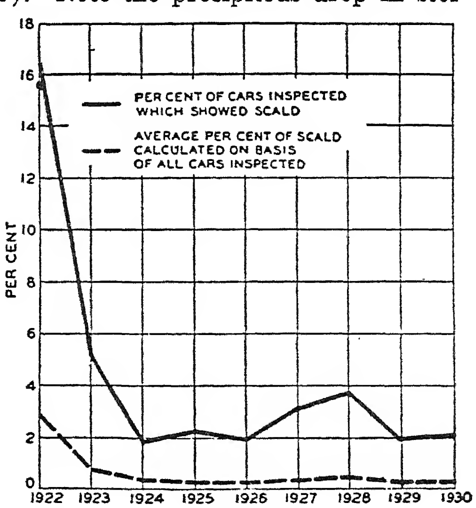

FIG. 10. AMOUNT OF SCALD IN BOXED APPLES FROM THE STATE OF WASHINGTON, AS SHOWN BY THE INSPECTION CERTIFICATES OF THE FOOD PRODUCTS INSPECTION SERVICE, U. S. DEPARTMENT OF AGRICULTURE. STEVENS.

[1] *Science*, n.s., 39: 733–743, 1914.

age rots at the time the information was being made available. The consumer could almost be given four potatoes for the price he formerly paid for three, and in addition to this, the work resulted in greatly extending the season in which sweet potatoes were available.

Here is another figure from data compiled by the same author (Fig. 10). It shows the effect of the development of the oiled wrapper upon the occurrence of scald on the apples that were passing into the channels of trade. The first extensive use of oiled wraps was in 1923 and they came into almost universal use on boxed apples in 1924. This chart shows the results on apples from Washington State, where the treatment was speedily put into practise, but oiled paper is now used as a preventive for scald in Canada, England, Switzerland, Australia, New Zealand and South Africa as well as in the different sections of the United States.

Rose and Lutz have recently cleared up a serious controversy in regard to bruising and freezing injury in car-lot shipments and found a remedy that promises to eliminate the trouble.

Items like these could be greatly multiplied. Every study that has been mentioned in the present discussion and many that have been omitted have had their beneficial effects in one or more phases of the industry. Various methods of precooling have been developed, market surveys and studies have been made, market pathologists located in the large cities, receiving point and shipping point inspection established, and above all out from the office of the chief of the Bureau of Plant Industry has gone a continuous stream of letters giving carefully balanced decisions, based on intimate knowledge of the findings of research and furnishing a powerful directing hand in the gradual adjustment of industry.

Losses have not been eliminated, however. Here are some figures showing the average claim per car paid by the American Railways in 1932.

Product	Loss and damage per car
Tomatoes	$24.89
Lettuce	19.44
Carrots	18.35
Watermelons	17.24
Cantaloupes	17.18
Plums and prunes	16.16
Grapes	14.80
Asparagus	13.31
Peaches	11.87
Pears	10.48
Oranges	6.20
Apples	5.88
Onions	4.37
Potatoes (sweet)	3.27
Potatoes (white)	1.05

Perhaps the claim on eggs of $3.95 a car and that on glass of $1.07 a car should have been included with this list. Why need the loss on tomatoes be more than 6 times that on eggs and that on sweet potatoes 3 times and that on apples 5 times as great as the loss on glass? Either the response of the plant material is not sufficiently known or else the available knowledge has not been properly standardized and applied.

The total claims paid by the American Railways on freight shipments of fresh fruits and vegetables in 1932 was $7,203,145, almost equalling that paid on all other commodities, although representing but 3 per cent. of the total cars handled. These figures do not include the losses in shipment by express nor those by boat and truck, nor do they include the losses in storage and in the wholesale and retail markets. The total would run into an enormous figure.

These losses, however, are being reduced. With allowance made for changes in volume of traffic the freight railway claims on fresh fruits and vegetables were 18 per cent. lower in 1932 than in 1930, a reduction of more than $2,000,000. This item in itself represents the removal of a considerable bar-

rier between the producer and consumer.

It might at first seem that the prevention of loss in a harvested product would be of benefit only to the party that carried the responsibility at the time the loss was likely to occur, but the charge for market operations is based on a supposed loss that must be passed along in the cost to the consumer. I was very much interested a few years ago in a remark by one of our largest brokers and exporters in regard to a serious and confusing disease of apples. He said in effect: "Professionally and ethically I am very greatly interested in the control of this disease, but insofar as my own business and profits are concerned, I have no interest whatever." To him the disease was only an additional hazard that made the failure of his less experienced competitor more certain. The consumer must ultimately pay for the spoilage either in the quality or cost of the product.

The botanical foundation and background that has been developed for shipping and marketing operations has brought the consumer many and varied benefits in character and quality of food.

It may be worth while raising the question whether the consumer has been given the opportunity of knowing that he has received benefits and more particularly as to whether he has been furnished with information in a form that will enable him to use the available botanical knowledge in the purchase and care of perishable food products. It has become the firm conviction of the dealer and tradesman that the consumer buys entirely with his eyes. I have heard it repeatedly from dealers that a cent's worth or less of shredded paper of the proper color (a by-product of apple scald treatment) when scattered over the top of a package of fruit will result in the consumer paying 25 cents to 50 cents premium for the package when displayed in comparison with undecorated fruit. To the extent to which this is true we can hardly say that we are very far removed from the days when the pioneers traded glass beads to the Indians in exchange for costly furs.

Has the botanist done his duty in seeing that information has been furnished to the consumer in an interesting and usable form? Should not our colleges and high schools give enough attention to the laws governing the behavior of harvested products to give the student an attitude of further inquiry? Is there any reason why the magazines that carry recipes for cooking plant products should not also carry short articles in regard to their selection and care? If we are to have dated coffee, why not dated vegetables or something equivalent?

It would seem that a better understanding on the part of the consumer of the products with which he is supplied might result in decided benefits both to himself and to the agricultural industry as well.

THE CHEMISTRY OF THE HORMONES FROM A STRUCTURAL STANDPOINT[1]

By Dr. VINCENT DU VIGNEAUD

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In the present review we shall attempt to evaluate what we actually know of the chemical structure of the hormones. The immense amount of activity in the endocrine field is bringing many hitherto inaccessible hormones within the scope of attack of the chemist, and it may be interesting to sum up at this time just what has been accomplished to date on the hormones from a structural standpoint. In so doing we may appreciate more fully what is yet to be accomplished.

It should be realized that very little can be done from a structural standpoint until the hormone is isolated in the pure chemical form. This can not be overestimated. It is true that with highly active but impure preparations one can obtain some idea as to the stability of the compound and some suspicions as to what types of groupings are present, but the real chemical work must rest on isolation of the hormone in crystalline form.

In the chemical attack on a hormone, isolation is, therefore, the first goal. The question of the chemical structure follows, intermingled with hopes of synthesis, for it is always the hope of the chemist to be able to synthesize within the chemical laboratory what is found in nature. However, the chemical attack is not finished with the isolation and synthesis of a hormone. There still remains the very intriguing problem of studying what particular groups in the molecule are responsible for its physiological action, and the synthesis of other compounds of analogous structure in the attempt to find a synthetic product of somewhat similar physiological action but more fitted for a particular clinical use. This is well exemplified by the study of epinephrine and the synthesis of epinephrine-like compounds, and the study of derivatives of thyroxine.

Another interesting phase of the chemistry of the hormones is the study of the relationship of a hormone to other physiologically significant compounds from a structural standpoint. Often this leads to an appreciation of underlying physiological relationships not otherwise appreciated. The importance of this has been particularly brought out in the investigations of the female sex hormone. This structural study has brought out the relationship of this hormone to the male sex hormone, cholesterol, cholic acid, ergosterol, Vitamin D, certain carcinogenic substances, certain cardiac glucosides (strophanthin) and even to certain alkaloids. Closely related to this aspect of the work is the study of the precursors of the hormone and their final metabolic fate.

Of the host of hormones that occur in the body, so far, only two have been synthesized in the laboratory. Four more have been isolated in crystalline form, but of these four we have a clear insight into the structures of only two of them. It is, therefore, quite apparent that the field of the chemistry of the hormones is in reality quite in its infancy. A great number of the hormones

[1] Presented in the symposium, "A Survey and Evaluation of the Present Status of Endocrine Investigation," held by the Medical Sciences Section of the American Association for the Advancement of Science, at the University of California, June 19, 1934.

which are now recognized solely by their physiological action remain to be isolated in pure form, their structures to be elucidated, and finally to be synthesized. There must be, indeed, a vast number that still remain to be recognized. It seems to me that it would be presumptuous for us to think that we recognize all the hormones at the present time, even as it was some years ago to think that the vitamins could be summed up in "A, B, C."

The two hormones to which I refer as being the only ones that have fallen under the synthetic attack of the chemist are, of course, epinephrine and thyroxine. Their synthesis represents the high point of the application of organic chemistry to the endocrines. The beautiful work that led to their isolation, their proof of structure and their synthesis serves as a stimulus for the attack on the other hormones.

The working out of the structure and synthesis of epinephrine soon followed its isolation in crystalline form. The isolation itself followed surprisingly quickly after the demonstration by Oliver and Schaeffer in 1894 that the adrenal gland contained a blood pressure raising principle. Abel succeeded in isolating a derivative of the hormone responsible for this action in 1901, and shortly thereafter Takamine obtained the free base in crystalline form. The structure of the hormone was elucidated through the joint efforts of many workers in the field within a couple of years and found to be as shown in Fig. 1.

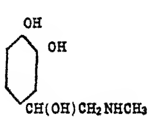


FIG. 1

It was finally synthesized by Stolz and by Dakin. The synthetic compound was, of course, the optically inactive form. The resolution worked out by Flächer led to the preparation of both the levo and the dextro epinephrine, and the levo epinephrine was found to be identical with the naturally occurring hormone. As is well known, the levorotatory epinephrine is 14 times as active as the dextro isomer, which emphasizes the importance of spatial configuration in connection with the hormones. This successful application of organic chemistry to the endocrines naturally directed much attention to this most interesting field and stimulated work on the other hormones.

Knowledge of the structure of epinephrine also initiated synthetic work in compounds closely allied to it in structure in order to find out which groupings are responsible for the activity of the compound. From the work of Barger and Dale it soon became apparent that the presence of the hydroxyl groups on the benzene ring is extremely important for the blood pressure raising action and that the absence of these groups results in a great reduction in activity. The presence of the alcoholic hydroxyl group on the side chain is also necessary for the high degree of activity of epinephrine, but it is not nearly so important as the phenolic groupings. I think, though, that it is fair to say that the chemist has so far failed to synthesize a more active pressor compound than *l*-epinephrine.

As I mentioned, the study of the precursors of a hormone is of much interest. In the case of epinephrine its structure immediately calls to mind the possible relationship to the amino acids, phenylalanine, tyrosine, dihydroxyphenylalanine and their decarboxylation products (Fig. 2). It is also interesting in this connection that the skin contains an enzyme "dopase" which converts dihydroxyphenylalanine to melanin, a deeply pigmented compound, and that there may be some relationship of this to the pigmentation or bronzing of the skin that occurs in Addison's disease.

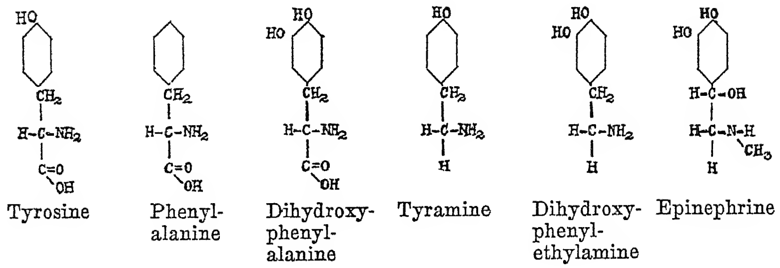


FIG. 2

It has been suggested that a precursor of epinephrine, possibly dihydroxyphenylalanine, is not used up properly by the diseased gland and upon its accumulation is acted upon by this enzyme "dopase" and is laid down in the skin as this pigment.

The evolution of our knowledge of the hormone of the thyroid proceeded at a much slower pace. An interval of 19 years elapsed between the separation of a quite potent fraction of the thyroid and the isolation of thyroxine by Kendall in 1914. It then required 12 years before its structure was finally worked out. From the beautiful work of Harington and Barger, we now know that thyroxine has the structure shown in Fig. 3. In an amazingly short period of

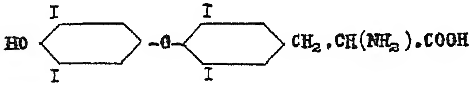


FIG. 3

time Harington and Barger accomplished its synthesis. The synthetic product required resolution for the final step in producing a compound identical with the naturally occurring hormone. Again it turned out that the levo or naturally occurring form was more active than the optical antipode.

In considering the structural relationship of thyroxine and other substances in the body, the similarity in structure with tyrosine was rather suggestive that this amino acid may also be the precursor of thyroxine. Furthermore, diiodotyrosine has been isolated from the thyroid gland.

It is also of much interest that Harington and coworkers have found that diiodothyronine is effective by mouth in treating myxoedema and that it seems to lead less likely to too high a basal metabolic rate upon over-dosage. This is an excellent example of what I meant by the possibilities in a study of compounds closely related in structure to a hormone of producing a substance that may have a certain advantage from a particular clinical standpoint.

These two hormones represent then the only ones of which we know conclusively the chemical structure. We do indeed have a long way to go, but the path is such an interesting one that we do not notice the time consumed in our gradual progress.

I said earlier that four other hormones had been isolated in crystalline form in addition to epinephrine and thyroxine, and that the structures of two of these were fairly well understood. These two are the female and male sex hormones. The structure of theelin, the so-called female sex hormone isolated by Doisy and by Butenandt in 1929, is quite well worked out. The conception of its structure by Butenandt rested on certain developments in the study of cholesterol. When the relationship of theelin to cholesterol was surmised, and when the general structure of cholesterol was realized, the possible structure of theelin became evident. It had earlier

been thought that the structure of cholesterol was that shown in Fig. 4.

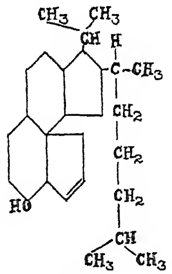


FIG. 4

But Rosenheim and King pointed out that a structure of the chrysene type would not only explain all that the above structure would, but would also explain certain reactions of cholesterol that this first structure would not. Windaus and Wieland quickly saw the truth in this suggestion and, by reinterpretation of old data and the obtaining of new, worked out a structure of cholesterol which seems to be the true one. It is rather generally agreed that the structure of cholesterol is as seen in Fig. 5.

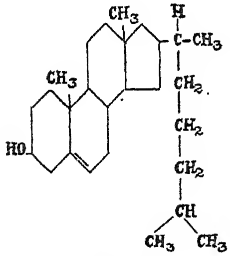


FIG. 5

With keen perception Butenandt realized the relationship in structure between theelin and cholesterol, and through clever deductions suggested the formula in Fig. 6 for the female sex hormone. Later he presented chemical evidence in favor of this structure. It must be pointed out, however, that this structure is not entirely proven; there are still points about it that must be ascertained. This work is going forward rapidly in the laboratories of Doisy, Marrian and Butenandt, and it will probably not be long before the entire story of the chemical structure of this important compound will be revealed.

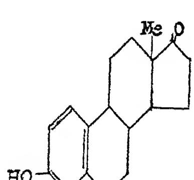


FIG. 6

Theelol, the trihydroxy oestrogenic compound, isolated from pregnancy urine by Marrian and by Doisy, is closely related in structure to theelin, and in fact Butenandt has been able to convert theelol to theelin in the laboratory by a dehydration reaction. If the structure of theelin is that which we have just indicated, theelol must then have the structure shown in Fig. 7.

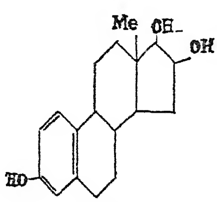


FIG. 7

The male sex hormone is, interestingly enough, apparently closely related in structure to theelin. Butenandt has suggested the structure for the compound he has isolated in Fig. 8. This,

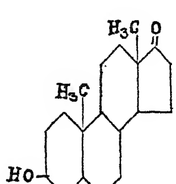


FIG. 8

of course, remains to be confirmed by conclusive chemical proof. The work on this compound is extremely difficult because of the paucity of material; for example, 25,000 liters of male urine

were required to produce only 15 mg of the crystalline hormone.[2]

The relationship chemically and physiologically between Butenandt's hormone and that of Koch and of McCullagh, neither of which, however, has been isolated in crystalline form, and the relationship between the latter two, is not entirely clear. Koch has recently presented some evidence that his compound prepared from bulls' testes may be different from that of McCullagh prepared from male urine.

There have also been isolated certain oestrogenic compounds from the urine of other animals and from plant sources and also certain substances isomeric with theelin whose chemistry is still to be worked out.

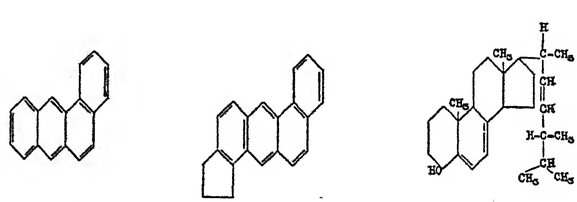
Another most interesting turn of events that followed closely the realization of the structure of theelin and cholesterol is the fact that certain carcinogenic substances found in coal tar by Kennaway and coworkers were, peculiarly enough, related to these in structure. The synthesis of other carcinogenic substances and the testing of them for oestrogenic activity and *vice versa* soon followed. It has been shown by the work of Cook, Dodds and coworkers in England that certain of these substances, such as 1 : 2 benzanthracene and 5 : 6 cyclopenteno–1 : 2–benzanthracene, possess both carcinogenic and oestrogenic activity.

[2] Since this paper was submitted Ruzicka has achieved the artificial preparation of this hormone (Androsteron) from cholesterol.

This work has also led to the surprising finding, based again on structural relationships, that Vitamin D derived from irradiated ergosterol also possesses some oestrogenic activity. These studies of Cook and Dodds have also led to the preparation of other synthetic compounds of a high order of oestrogenic activity comparable with that of the hormones themselves. The working out of the underlying physiological and possibly pathological relationships based on these findings will no doubt lead to very significant results. I can not believe that the behaviors just mentioned can be merely accidental manifestations of metabolically unrelated compounds.

The other two hormones that exist in crystalline form but whose structures are as yet unknown, are insulin and cortin. Kendall recently announced the isolation of a crystalline compound from the adrenal cortex of the empirical formula $C_{20}H_{30}O_5$. Wintersteiner, Pfiffner and Vars have also reported results which indicate that cortin is a non-nitrogenous compound. There is little use in discussing the chemical properties of cortin at the present time, for certainly more definite information concerning its structure will soon be available from a study of the crystalline compound.

The isolation of insulin in crystalline form by Abel followed within 5 years the announcement of Banting and Best of the preparation of active extracts of the pancreas. Since that time intensive



1 : 2–benzanthracene 5 : 6–cyclopenteno–1 : 2–benzanthracene Ergosterol

FIG. 9

work has gone forward in many laboratories on the crystalline insulin and many interesting facts have been brought forth. Yet in all frankness, we must admit that we know practically nothing of the structure of insulin. It is true that certain amino acids have been isolated from the crystalline material, but this has given little insight as to structure except to confirm the idea that insulin is a protein substance. The isolation of these amino acids, however, was necessary because at the time that that work was undertaken there was talk of a peculiar sulfur linkage and of the possibility of there being an unusual guanido compound present. Further, it was not known whether the imidazole reaction was due to histidine or the phenolic reaction due to tyrosine. The isolation in crystalline form of cystine and tyrosine, arginine and histidine was therefore significant. The study of the nitrogen distribution by Wintersteiner was also quite necessary but revealed no unusual distribution. A fact that is probably of the greatest significance is strangely a negative one, and that is, that no one has so far isolated from insulin any constituent other than those which can be found in other proteins.

It is therefore quite evident that there is not one iota of proof as yet for the existence of a prosthetic grouping in insulin. The chemist would like to believe that there does exist such a group, for it would be in its isolation or in its identification in the molecule that the hope of the chemist lies. On the other hand, I must equally emphasize that no evidence has been presented that rules out the existence of such a prosthetic grouping. The point I wish to make is that discussion concerning an active grouping rests purely on hypothesis, and evidence for it remains for future research to bring forth, a fact emphasized by Jensen in his recent excellent review of the "Chemistry of Insulin."

The importance that Abel, Geiling and coworkers attached to the presence of sulfur in the crystalline product has been entirely justified by subsequent research. The sulfur is a vulnerable point in the structure of insulin, and, as we have pointed out elsewhere, no one has modified or changed the sulfur of insulin without affecting potency, although it may be true that insulin can be destroyed without affecting its sulfur. The fact that insulin can be destroyed without affecting the sulfur does not detract from the fact that the disulfide is necessary to the action of insulin. There may well be other groups necessary to the insulin action.

There is another point I would like to mention in connection with the chemistry of insulin and that is the heat precipitation reaction. As far as we know, this is the only reaction characteristic of insulin material. When insulin is heated in dilute acid a precipitate is formed which is inactive but upon treating with dilute alkali it dissolves and is once again active. It furthermore regains its solubility in dilute acid and the entire process can be repeated. Inactivation by a variety of agents, such as acids, alkali and reducing agents, causes as well the heat precipitation reaction to disappear. The fact that activity and heat precipitation seemed to accompany one another led us to believe for a time that the same groupings were involved in both behaviors. However, we have obtained a fraction of insulin still heat precipitable but inactive, which of course makes the above hypothesis untenable. Of particular significance in connection with the heat precipitation is the fact that the regenerated insulin is a changed insulin having certain different physical properties. It gives one hope that one may be able to further modify insulin without destroying its hypoglycemic action and possibly to modify it to such an extent that it will

be changed enough to become resistant to proteolytic enzymes and thereby open the possibility of mouth administration.

Many other hormones have been highly purified but have as yet resisted the efforts that have been made to crystallize them. Much has been done on the hormones of the post pituitary, the parathyroid hormone, secretin, progestin[3] and the gonadotropic hormone excreted during pregnancy. All these exist in quite highly purified form. Of the hormones I have just mentioned all of them except progestin seem to be of protein or polypeptide-like structure. There is also the host of hormones which are known mainly through their physiological behavior, but knowledge of their chemistry is most meager. A discussion of their structural chemistry would be unprofitable at the present moment as so little is known of their actual chemistry. I would, however, like to say a few words about the present status of our knowledge of the chemistry of the post-pituitary hormones.

The physiological action of the extracts of the post pituitary have long been recognized and methods of assay have been available for many years, yet the compound or compounds responsible for the physiological activities have defied efforts at their isolation. The pioneer isolation work was here again due to Abel. It has been generally recognized that the melanophore principle is a separate one, but there is still a division of opinion as to whether the pressor, antidiuretic and oxytocic activities are due to a single mother substance or whether there exist separate pressor and oxytocic principles. Abel is still in favor of his unitarian hypothesis, while Kamm is the main proponent of the multiple theory. Kamm and coworkers have succeeded in isolating preparations of exceedingly high pressor but practically no oxytocic activity, which he called "pitressin," and preparations of high oxytocic activity with only a small amount of pressor activity, which he called "pitocin." These preparations are the most potent that have so far been isolated. The decision as to whether or not these compounds exist in the gland as separate principles or together as a mother substance must await future research. It might be well to allow the question to rest until the substances are isolated in crystalline form and their structures worked out, for then it can be ascertained whether or not they could have been linked together.

In working on the chemistry of these pressor and oxytocic principles we have recently obtained evidence which we feel clearly demonstrates that sulfur in the disulfide form is present in both the hormones, pitressin and pitocin.

Kamm and Grote were good enough to place in our hands a series of preparations of pitressin and pitocin of varying degrees of potency which enabled us to study their composition in order to detect if possible any distinguishing chemical properties between these two principles. We wished to find out if there were any characteristic chemical changes with increasing concentration of the active principles which might be useful in following, from a chemical standpoint, further attempts at their isolation. As a preliminary attack along these lines with Messrs. Sealock and Sifferd we have determined the sulfur, nitrogen, cystine, tyrosine, arginine and histidine contents of the various fractions. A striking difference was found in the cystine content of the highly purified preparations of pitressin and pitocin as determined by the Sullivan method. For example, a sample of pitocin possessing 500 units of oxytocic activity per mg contained 3.05 per cent. sulfur and had a cystine value of 8.96 per cent., whereas a sample of pitressin containing 200 units of pressor

[3] Allen and Wintersteiner have just announced the isolation of crystalline progestin with the empirical formula of $C_{21}H_{30}O_2$.

activity per mg gave only a faint Sullivan reaction, although 3.10 per cent. sulfur was present. In the case of both series of preparations increasing potency was attended by an increase in sulfur content. Another finding which may be of significance was the high tyrosine or rather phenolic value of both series of fractions, which markedly increased upon concentration of the active principles. Of the two samples mentioned above the pitocin contained 14.3 per cent. tyrosine, while the pitressin sample contained 10.5 per cent. Further work is being carried out along these lines and in further attempts to purify the active principles.

The sulfur of these preparations attracted our attention, and we felt it would be interesting to study the reduction of the pitressin and pitocin with cysteine. Under conditions which we have shown that insulin is completely inactivated by cysteine, we have found, with Mr. Sealock, that pitressin and pitocin retain their activity. Secondly, benzylation of the reduced pitressin and pitocin causes disappearance of their physiological activity. The treatment of the unchanged pitressin and pitocin with benzyl chloride resulted in no loss of activity. This clearly shows that we had obtained actual reduction of the disulfide to the sulfhydryl form of pitressin and pitocin by the action of cysteine and secondly that the reduced forms of these hormones are active. Probably what is most significant, however, in these experiments is the fact that they present almost conclusive proof that the hormones themselves actually contain sulfur, although it had already been known from the earlier work of Sullivan and Smith that loosely bound sulfur was present in extracts prepared in the usual fashion from the Standard Powdered Pituitary and that it tended to parallel the activity.

There is one other point I would like to make before closing this discussion. The isolation of adrenaline and thyroxine and their turning out to be relatively simple low molecular weight compounds has led us to expect that all hormones would likewise be of the same order of complexity. Furthermore, the fact that thyroxine seems to be linked with a protein as thyroglobulin in the thyroid gland has by analogy tended to lead us to expect that, where a hormone is isolated in crystalline form and exhibits protein behavior, there must be linked to the protein a prosthetic grouping. In other words, in the case of the hormone of the thyroid gland, it could be regarded that it was the prosthetic grouping that was isolated in crystalline form, whereas in other instances it might be the protein plus prosthetic grouping that happened to be isolated. We may have to keep our minds open to the possibility that a protein might in itself have physiological behavior not necessarily attributable to a prosthetic grouping as such. With the growing insight into the fact that enzymes may be proteins and with the realization of the rôle of proteins as toxins, antitoxins, antigens, antibodies and the like, this idea may seem more and more possible.

RAINMAKERS ON THE PLAINS

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UP to the Civil War the Great Plains of this continent stood condemned as the Great American Desert. Buccaneer Coronado, the first white man to penetrate the domain of the buffalo in the sixteenth century, was also the first to christen it a desert. Three centuries later the fiction of the plains desert was confirmed by such prominent expeditionists as Zebulon M. Pike, John Bradbury, Major S. H. Long and others. That the pronunciamentos of these men were taken seriously is indicated by the fact that all good geographical textbooks described the Great American Desert to and even after the fifties. Yet, at this time and immediately following it, history records the greatest settlement of these drier lands.

That early settlers entered this once so-called desert area so precipitously was not merely the result of a leap-frog method of advance. Although mechanical devices facilitated the pioneer's advance after the middle of the nineteenth century, more significant was the fact that a desert concept was simultaneously exploded by what was then considered a newly discovered meteorological doctrine. It was alleged that the presence and activity of the white man was altering a set of meteorological phenomena which made for aridity and that the belt of greater rainfall was migrating westward.

The early plainsman's psychosis made it relatively simple to promulgate what in retrospect seems a rather ludicrous idea. He was as replete with self-reliance and faith in the Almighty as he was devoid of worldly means and accurate knowledge of the plains. Lack of information and a naïve disposition towards the powers that be, other than political, rendered him very impressionistic. The vigorous life of the frontier made it highly soothing to his ego to hear that he was wrestling with the moulding forces of the universe. That his presence and activity on the plains should effect a change in a cosmic law pleased him more than a little. Agents to proclaim the new order were not lacking. They were mainly real estate men, railroad-promoters and ministers.

It is to be remembered that every pioneer had heard much about the Great American Desert. That such a desert never existed he did not suspect. Yet here he found himself on the plains, producing crops with varying success. The conclusion was inescapable that annual precipitation had increased. The varying amounts of rainfall further encouraged the false conception concerning increased rainfall. The late seventies and early eighties were relatively moist years. In contrast to them stand the years of the late eighties and early nineties. The misconception naturally received its greatest fillip during the former period.

One of the earliest expressions of the theory of the westward migration of rainfall is to be found in Gregg's "Commerce of the Prairies," which appeared in the forties. He writes of the matter as follows:

> The high plains seem too dry and lifeless to produce timber; yet might not the vicissitudes of nature operate a change likewise upon the season? Why may we not suppose that the genial influences of civilization—that extensive cultivation of the earth—might contribute to the multiplication of showers, as it certainly does of fountains? Or that the shady groves,

> as they advance upon the prairies, may have some effect upon the season? At least, many old settlers maintain that the droughts are becoming less oppressive in the West. The people of New Mexico also assure us that the rains have much increased of latter years, a phenomenon which the vulgar superstitiously attribute to the arrival of the Missouri traders. Then may we not hope that these sterile regions might yet be thus revived and fertilized, and their surface covered one day by flourishing settlements to the Rocky Mountains?

The Mormons of Utah were next to encourage the belief that rainfall was increasing in the West. The erroneous speculation of these people on this matter had its inception in the observation that the level of Salt Lake was gradually rising. In popular discussion it was soon suggested that the cultivation of the desert lands by the system of artificial irrigation had brought about the climatic change. Prominent members of the United States Geological Survey were prompt to deny such an absurd hypothesis. Local wiseacres to perpetuate and spread the misconceptions, however, were not lacking.

By the end of the Civil War the miasma of the misconception of increased rainfall was already at large on the plains. In 1866 the Commissioner of Public Lands recommended a measure to Congress which would compel the plains pioneers to forest a high percentage of their land with the view of increasing rainfall in the region. A few years later Congress heeded this suggestion by the Act of 1873, which purported to encourage the growth of timber on the prairies. The Act of Congress gave statutory dignity to a conception which was shortly to make the plains the mecca of homeseekers from regions as remote as central Europe.

The seventies and early eighties constituted the boom period of the plains. Overnight there sprang up a motley array of local boosters who described and advertised the West as never before. The westward migration of rainfall constituted the dominant note of these voices in the wilderness. The Reverend Mr. C. S. Harrison, of York, Nebraska, in a prize essay on the topic in 1873 expressed the advanced belief on this matter at that date. He says, in part, as follows:

> The curse of God falls heavily on the people who ignore His grand design and rob the lands of forests. Egypt was once one of the most fertile and wealthy countries. Remains of petrified forests yet attest what her defences were against the drifting sands. These were destroyed and Egypt became a desert. Palestine was a land flowing with milk and honey. . . .
>
> This world was made for man's comfort, and it is placed in his keeping; if he abuses it, retribution is sure to follow. . . .
>
> Portions of Utah, considered rainless, have been watered by showers since trees have been planted. There is some foundation for the belief that rain follows the white man. Providence seems to encourage the adventure of men as they push westward. The mythical desert will doubtless be covered with beautiful groves and fruitful orchards even to the base of the Rocky Mountains. In many places where streams and springs have been dried up by the removal of the trees, they have been recalled by the planting of their protectors.

The wide, open tracts of land on the plains which seemed to invite cultivation stirred the imagination of many Easterners as well as of thousands of home-seeking Europeans. Information concerning the new country in the West was read with avidity. Railroad and community brochures were printed and circulated gratuitously. Other printed material, which purported to be of a more unbiased nature, also found a ready and wide-spread market and consequently appeared in ever-increasing numbers. Of such a nature was a booklet, "Nebraska As It Is" (1878), by L. D. Burch, then editor of the Chicago *Commercial Advertiser*. The author's flattering descriptions of this state have been excelled by only a few writers. With reference to the rainfall in the state, the author says:

> From the increasing rainfall of the state, it is also evident that at no distant day the whole state as far as to its western limits, will have an abundant rainfall for all the needs of the agriculturalists.

In another chapter he says:

> If the drouth and Hot Winds of the early years were serious drawbacks to early settlement, they certainly are not in these later years, for they have passed away with the causes that produced them. There is far more apprehension of excessive moisture among the farmers of the state today than there is of excessive and prolonged drouth or heat, and yet danger from this direction is almost entirely obviated by the admirable natural drainage of the country.

Nebraskans cherished this hope and conviction concerning the westward migration of rainfall. Conflicting reports were greatly resented. This is well illustrated in the instance of a report published by the Department of the Interior in 1879, entitled "Lands of the Arid Region." This report is based on information gathered by Major J. W. Powell when in charge of a United States geological survey in the West. He had spent years on the plains and could speak authoritatively on the subject by virtue of having traversed the region many times and also because of his scientific training. Time has largely vindicated his observations. His report in part runs as follows:

> The limit of successful agriculture without irrigation has been set at 20 inches, . . . at 20 inches agriculture will not be uniformly successful from season to season. Many drouths will occur . . . and it may be doubted whether, on the whole, agriculture will prove remunerative. On this point it is impossible to speak with certainty.

In his opinion the 100th meridian in this country constituted the line of demarcation between irrigable land and non-irrigable lands.

Nebraskans challenged the report. Robert W. Furnas and Martin Dunham, both prominent educators and political leaders in the state, sent a letter of inquiry to Professor Samuel Aughey and to C. D. Wilber at Lincoln, asking what facts there were to sustain such a report. Their reply illustrates that academic circles also shared in the belief of increasing rainfall in the West.

> Observation, experiment, and the highest scientific authority demonstrate that climates in the west are becoming moister; that rainfall is increasing steadily. This increase must extend until the plains east of Denver and Laramie receive sufficient rainfall to produce farm products without irrigation. . . . For these reasons we are compelled to say that any evidence of present dryness, where dryness exists, is evidence only for the present, and should not be used to cover these areas with the undeserved reproach of the curse of desert lands.

The question arises, What facts or data could be supplied to defend this position? In the report of the Nebraska State Horticultural Society, 1878–79, Mr. Wilber obliges us with his theories concerning this phenomenon:

> In a word, it is caused by the plow . . . it converts a desert into a farm or garden. . . . A desert however is the result of conditions that can be controlled by the genius and industry of man. . . . The moisture contained in the atmosphere over this new made surface of living green will not dissipate and pass away with the winds, as formerly, but will condense, by the well-known law, both as dew at night and into clouds, under the influence of electric currents. With the clouds comes precipitation, which will be greatly increased as the condensing surface increases by the constant efforts of the farmer to enlarge his domain of crops. . . .
>
> With a logic that cannot rest we are forced to this conclusion, that the agencies of civilization now in action are such as will secure a complete victory over the wilderness and waste places of western territory. The plow will go forward; "God speed the plow."

In 1880 appeared Samuel Aughey's "The Physical Geography and Geology of Nebraska." The book, in this instance, is as interesting and significant as its author. It is the first scientific treatise on the geology, geography,

climatology, flora and fauna of this state. The material it contains is nearly all based on first-hand information which the author had gathered in his many trips over the state. The book not only treats of a frontier region, but in and of itself it is also decidedly frontier in character. As such, it should move us to be generous towards the author and some of his visionary and strange conceptions.

Professor Samuel Aughey, Ph.D., LL.D., was the head of the natural science department in the University of Nebraska from 1871 to 1883. That he was a man of national reputation is indicated by the fact that he was a prominent member of the St. Louis Academy of Science, the Buffalo Academy of Science, the American Association for the Advancement of Science, the Iowa Academy of Science and other similar societies. Trained to be a theologian, he spent several years in the pulpit. It was in such a capacity that he came to Dakota City, Nebraska, in 1864. His interests, however, also encompassed things scientific, and he spent much time and effort studying geology, chemistry and botany. Upon his arrival in Nebraska he found an almost untouched field of study along these lines. In a few short years, through his field researches, he became one of the most respected, admired and popular scientific figures on the Nebraska plains. His theological training served him in good stead among the country folk of the state. Dr. A. E. Sheldon, secretary of the Nebraska State Historical Society, who knew Professor Aughey, says that next to God, Professor Aughey was the best known, liked and respected figure in Nebraska. Professor Aughey was the most outstanding champion of the rainfall-migration theory. His support of the theory gave it the stamp of scientific approval. Critics of the theory could hardly gainsay the words of a man who was at once a Ph.D. and an LL.D.

Professor Aughey's advocacy of the migration of rainfall was not the result of armchair speculation. No man had made closer observation and studies of the geography of the plains; few were better versed in scientific literature. He noted that precipitation data for the late seventies actually did show a slight tendency for increased rainfall. Lack of data covering a large period of time naturally made such slight increases a subject of fertile speculation. Other observations indicated the same tendency. Professor Aughey observed in his peregrinations over the state that many new springs had begun to flow. He also noted the "appearance of water in old creek beds, where it apparently had not been flowing for ages." He speaks of an alleged change in vegetation as follows:

> The changing vegetation of the State proves the same fact. There was a time within the memory of many now living when buffalo grass was the most conspicuous vegetable form west of the Missouri. . . . Now how changed. It has almost entirely disappeared for two hundred miles west of the Missouri. There is comparatively little of it now on the third hundred. Every year it is retreating further westward. Its place is supplied with grasses indigenous to moisture climates.

It must be admitted that the above observations can not be denied *in toto*. Possibly new springs did occur, and streams again did continue to flow in dry stream beds. That the type of grass did change seems doubtful, since no transformation in grasses has been noted in the unbroken fields.

Professor Aughey did not subscribe to every fabulous theory that proposed to explain the alleged increasing rainfall. He discounted secular reasons which were cited because he found no spontaneous causes to effect them so promptly and profoundly. He also discredited and criticized the popular belief that the railroad lines and telegraph lines were responsible for the alleged greater rain-

fall. Strangely enough, a wide-spread popular conception held that every yard of steel rail laid in the desert would draw from the heavens a gallon of water per annum.

Professor Aughey held that the planting of trees on the plains might be a helping cause to more rains, yet that such vegetation could not alone account for the greater amount of moisture experienced. He said:

> *It is the great increase in the absorptive power of the soil, wrought by cultivation, that has caused, and continues to cause an increasing rainfall in the state.*
>
> Any one who examines a piece of raw prairie closely, must observe how compact it is. Every one who opens up a new farm soon finds that it requires an extra force to break it. There is nothing extraordinary about this. For vast ages the prairies have been pelted by the elements and trodden by millions of buffalo and other wild animals, until the naturally rich soil became as compact as a floor. When rain falls on a primitive soil of this character, the greater part runs off into the canyons, creeks and rivers, and is soon through the Missouri on its way to the Gulf. Observe now the change which cultivation makes. After the soil is broken, a rain as it falls is absorbed by the soil like a huge sponge. The soil gives this absorbed moisture slowly back to the atmosphere by evaporation. Thus year by year as cultivation of the soil is extended, more of the rain that falls is absorbed and retained to be given off by evaporation, or to produce springs. This, of course, must give increasing moisture and rainfall.

To show that this theory had elements of truth in it, Professor Aughey cited an experiment he had made on several occasions. Blocks of "sod soil" and of cultivated soil, of equal size and in close juxtaposition, were weighed before and after rains, and in each instance it was found that the latter absorbed a much greater amount of moisture. The experiment was varied somewhat and carried on many times to eliminate chances of error. The cultivated soil, the professor noted, absorbed as high as ten to twelve times the amount of moisture the sod soil did. To be conservative in the matter, he sets the general ratio in this matter as eight to one.

Professor Aughey's opinion concerning the alleged westward migration of rainfall appeared in many publications and was received with enthusiasm both in America and Europe. The revolutionary nature of this theory made it a topic of conversation. Whatever inertia it still possessed was completely and effectually overcome by the impact of railroad advertising. Several hundred thousand copies of descriptive pamphlets prepared by Aughey were promptly circulated by the railroads. The unparalleled influx of settlers into Nebraska in the late seventies and early eighties stands in part as a permanent tribute to the achievements and opinions of Samuel Aughey.

C. D. Wilber, LL.D., was Professor Aughey's satellite as a frontier publicist. Being a man of many interests and not being particularly adept in any field of study, he possessed the happy faculty of rationalizing as his inclination dictated. Mr. Wilber, like many of his contemporaries in Nebraska, owned some real estate which it was hoped would rise in value. It is not altogether peculiar that he and the other proprietors greatly deplored the unfortunate attitude and conception Easterners held concerning the plains region—particularly that portion in and about Nebraska. To dispel the false conception of Easterners, Mr. Wilber wrote "Nebraska and the Northwest" (1881).

Mr. Wilber received his inspiration for his work as well as much of the actual material from Professor Aughey's "The Physical Geography and Geology of Nebraska." The latter work, although it frequently soars into the realm of fancy, reflects the spirit of the scientific method. Wilber's work is of a more popular nature and shows clearly what the author liked to believe was true of Nebraska. His descriptions and opin-

ions are so positively naïve, as well as misleading, that we shall quote somewhat liberally from his chapter on rainfall. Following are some of Mr. Wilber's opinions as they bear on this subject:

> By the repeated processes of sowing and planting with diligence the desert line is driven back, not only in Africa and Arabia, but in all regions where man has been aggressive, so that in reality there is no desert anywhere except by man's permission or neglect. . . .
>
> Palestine is now comparatively a desolation, for the simple reason that the gardener's occupation is gone. It once sustained, as we are credibly informed, a vast population. Nor is there any doubt that both these noted valleys can be brought back to their former productive ability by applying the same means that have been so long neglected. . . .
>
> It requires only the condensing surface of growing verdure; it may be of trees or shrubs or growing grain, over large areas; or, in short, just such a changed surface as man necessarily brings about as a tiller of the soil, to compel the moisture to make clouds form in the atmosphere, instead of being dispersed by the daily radiation of solar heat. . . .
>
> . . . the Indians are, and, as far as we know, have always been, co-workers with the natural forces that maintain and extend desert conditions. . . .
>
> To those who possess the divine faculty of hope—the optimists of our times—it will always be a source of pleasure to understand that the Creator never imposed a perpetual desert upon the earth, but, on the contrary, has so endowed it that man, by the plow, can transform it, in any country, into farm areas.

The work of Samuel Aughey and of C. D. Wilber made the theory of the westward migration of rainfall acceptable in the best of scientific circles. Institutions that wished to advertise the West could now point to the best of authorities for their optimistic claims concerning the plains. Those who were contemplating a new home and a new start in life on the plains responded unhesitatingly to the sirens of the plains.

Orange Judd, editor of the *Prairie Farmer* at Chicago, was one of the most widely known agricultural writers in the United States at the close of the nineteenth century. Mr. Judd was a staunch believer in the alleged westward-migration-of-rainfall theory. His opinions on the matter, as reflected in his magazine, were read most widely by the rural people, who were most likely to respond to the alleged attractions of the plains lands.

Mr. Judd was also an eloquent speaker and so was invited to deliver an address at the Nebraska State Fair at Lincoln, in 1885. He accepted and delivered an address on the causes and importance of increasing rainfall in Nebraska. His statements are not characterized by brilliant reasoning on the subject; however, such reasoning was hardly required by the temper of the times. The gist of Mr. Judd's address was that there is always enough moisture in the sky above to furnish a rain if only some way could be devised to bring it down from overhead. He says in part as follows:

> There is just as much water in the bright, clear sky above you at this hour as there is on the most densely cloudy day, or as there is during the severest rain storm. Electrical conditions, or currents of colder air, or other influences lower the temperature, the hidden moisture comes out and falls, as I have described.

Of course, Mr. Judd's major premise concerning the amount of moisture in the air is fallacious. Also, his description of how the moisture is to be condensed is vague and misleading. However, the audience and the speaker found it convenient and satisfying to believe what the substance of the speech indicates. The audience was assured, in conclusion, that

> As neighboring Kansas settles up and breaks the prairie sod away out to its western border those parching winds that formerly came up into Nebraska and still come at some points, will be heard of no more.

All the railroads on the plains, with the exception of the Union Pacific, were built with the conviction that the land possessed agricultural possibilities. Expected through or terminal business hardly warranted such a gigantic and expensive undertaking. All these roads, therefore, set themselves to the task of settling the West. The advent of such encouraging prophets as Aughey, Wilber and Judd was most satisfying and gratifying. Pamphlets and brochures were soon prepared that embodied the alleged fact of westward migration of rainfall. These were circulated with abandon both in the United States and in portions of Europe from which settlers might be attracted.

The fiction of increased rainfall on the plains proved so popular and profitable as to evaporate all interrogations as to its validity. Only a cruel "weather man" could and did blast this effectively entrenched conviction. In the late eighties and early nineties occurred a series of dry years. Crop failure followed crop failure. Want and distress became wide-spread over the plains. A beautiful theory of increasing rainfall became but a haunting and mocking memory to thousands who saw their substance wasting and parching about them. Better than eighteen thousand prairie schooners passed east over the Missouri River bridge at Omaha in one season—never to return. Frequently towns which in the eighties had a population of several thousand had completely disappeared by the middle of the nineties. Caravan after caravan which had served to bring the pioneer family west was re-outfitted to carry it away from this land of deception. On many a prairie schooner the owners expressed their bitter hearts as follows:

In God we trusted,
In Kansas we busted.

ANIMAL CARTS

HOW MARMOTS, BADGERS AND BEAVERS SERVE AS SLEDS OR WAGONS

By Dr. E. W. GUDGER
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WHEN I was one of the graduate student body in zoology under Professor W. K. Brooks at the Johns Hopkins University years ago, among the other veils of ignorance which he attempted to lift from before our eyes was that behind which were hidden the works of the fathers of natural history. On those days he introduced at least one student to a field of study in which he has found very great pleasure.

I well remember the day when he brought out and opened before us the five great folio tomes of the "Historiae Animalium" of Conrad Gesner, published at Zurich 1551–1587. Little did I think then that years later I was to become well acquainted with that volume entitled "Historiae Animalium, Liber IIII, Qui Est de Piscium & Aquatilium Animantium Natura . . ." Tiguri (Zurich), 1554.

Of that talk by Professor Brooks I have a very strong recollection in a very poor memory of his telling us that Gesner stated that rats transported eggs in this interesting fashion. A rat lies on his back, others roll an egg up onto his belly where he holds it with all four paws, while the others grasping his tail drag him along—an animated sled—to their burrow. And as Professor Brooks spoke I could visualize the scene, and I have done so for 30 years—mistakenly.

About a year ago I prepared an article (now in press to appear in *Isis*) on the five early naturalists and their foundational work in ichthyology—Gesner standing fourth in the series. While engaged on this study (with this old story in the back of my head) I went to Professor Brooks's article on Gesner in the *Popular Science Monthly* (1895, Vol. 47) where on p. 57 I found the story told, not about the rat, but about a different animal, another rodent, the so-called Alpine mouse or marmot. But to exculpate myself, let it be said that this beastie and the other rodents are put by Gesner in the section "De Muribus diuersis" of Liber I of his old folio—our copy of which has wooden covers and brass clasps.

And now being bone-tired with working for sixteen months on the problem of abnormalities in flounders, I am going to ease up the strain by going off at a tangent—ending in this subject named, about as far from fishes as can well be.

THE "ALPINE MOUSE" OR MARMOT AS A HAY SLED

Here is what Professor Brooks did say on this subject, as published in his article:

> They [the Marmots] make use of a peculiar device for bringing home their hay. If they have gathered a great quantity they need a wagon to carry it, and one of them lies down on his back, and, lifting his feet toward heaven, forms supports ["standards"] like those of a hay wagon between which the others pile the hay. When the cart is loaded, the other marmots take the tail in their mouths, drag their brother home like a sled, and, after unloading him, put the hay in their holes. As each one takes his turn of service as a sled, none of them have any hair on their backs at this season of the year.

This is translated from page 842 of Volume I of Gesner's "Historiae—De Quadrupedibus Uiuiparis" (Tiguri, 1551). Gesner gives a figure of the

Alpine mouse, but unfortunately not of the scene depicted.

This story is also related by Edward Topsel, whose "History of Four-footed Beasts" was published at London in 1607. This not being available, I quote from the second edition (London, 1658, p. 407). Topsel tells us that his book was largely "Collected out of the Writings of Conradus Gesner." However, he introduces an interesting variation from Gesner's account, which shows that he had either had experience or observation of hay-hauling. Since the hay was liable to slip off this animated hay sled, some precaution had to be taken. Here is Topsel's account, including the addition:

> Towards the feast of Saint Michael the Archangel, and of Gallus, they enter into their Caves; and as Pliny saith, they first of all carry provision of Hay, and green Herbs into their Den to rest upon, wherein their wit and understanding is to be admired; for like Beavers one of them falleth on the back, and the residue load his belly with the carriage, and when they have laid upon him sufficient, he girteth it fast by taking his tail in his mouth, and so the residue draw him to the Cave; but I cannot affirm certainly, whether this be a truth or a falsehood. For there is no reason that leadeth the Author thereunto, but that some of them have been found bald on the back.

It is difficult to keep a load of hay from slipping off a hay wagon or sled, so a "spring pole" is used. The larger end is permanently lashed to the front of the hay frame and, after the hay is loaded, the flexible pole is bent or sprung down lengthwise of the frame and lashed behind. In Topsel's account the rat's tail serves this same purpose.

However, Gesner was not the originator of this story but had it from Pliny the Elder (23 B. C.–79 A. D.), as he expressly notes. In Pliny's "Natural History," in the well-known translation of Bostock and Riley (London, 1890, Vol. II, Book viii, Chap. 55, p. 308), is found another interesting variant as follows:

> Some writers say that the male and the female [marmots], lying on their backs alternately, hold in their paws a bundle of gnawed herbs, and the tail of each being in turn seized by the teeth of the other, in this way they are dragged to their hole.

This is surely a fine illustration of cooperation in burden-sharing and it explains why all the members of a colony (males and females alike) are alleged to be found hairless in the dorsal region. However, John Timbs in "Strange Stories of the Animal World" (London, 1866, p. 372) alleges that "they use an old [and presumably otherwise useless] she marmot as a cart; she lies on her back, the hay is heaped on her belly and two others drag her home."

The Sieur de Beauplan lived seventeen years in the Ukraine (when I do not know) as "ingineer" to the King of Poland. He wrote "A Description of Ukraine," which was Englished in Churchill's "Collection of Voyages" (Vol. I, London, 1704). I quote him from the second edition (Vol. I, Pt. II, p. 542), London, 1732. He writes of a rodent which he calls bobaque or babaque, which seems to be our marmot or a very close relative. Of these beasties he writes thus not merely to adorn a tale but to point a moral concerning laziness:

> They are great sleepers and good managers, nature directing them to lay up provision, insomuch that one would think there were slaves among them, for they take those that are lazy and lay them on their backs, then lay a great handful of dry herbage upon their bellies, which they hold fast with their paws, or rather hands, because they make use of them almost as monkeys do: then the others drag those drones to the mouths of their burrows, and those creatures serve instead of barrows, whence they make them carry the provision into their holes. I have often seen them practice this.

The Badger as a Wheelbarrow

The badger is digger of burrows in the ground and as such needs to get rid of the "spoils" from his deep "earths."

To the average person this would seem to be a matter of some difficulty, but not to our old naturalist. Gesner on page 780 of his Volume I describes how it is done and Topsel translates him as follows:

> When they dig their den, after they have entred a good depth, for avoiding the earth out, one of them falleth on the back, and the other layeth all the earth on his belly, and so taking his hinder feet in his mouth, draweth the belly-laden Badger out of the cave, which disburdeneth her cariage, and goeth in for more until all be finished and emptied.

Here is found a change in the method of haulage. The badger's tail is short, so the motive power lays hold of the hind feet. Notice here Topsel's delightful indifference to the sex of the badger wagonette and his quaint spellings—I love his "avoiding."

This account of Topsel's has been often copied. For instance, it is found practically unchanged in the "Gentleman's Recreation" (1677) by Nicholas Cox.

The Beaver as a Wood Wagon

The allegation that an individual beaver may be used to transport bits of wood, just as the marmot is used for the transport of hay, we also owe to the "German Pliny," Conrad Gesner. It is found on page 338 of the volume quoted. Next there are three lines given to it in the first edition of Olaus Magnus's "Historia de Gentibus Septentrionalibus" (Romae, 1555, p. 604). This author's book is illustrated by so many quaint and interesting old woodcuts that I had hoped for one here, but the artist missed his chance.

It has not seemed worth while to translate either Gesner's or Magnus's statements; this has been done by old Topsel (1658) with suitable embellishments. Let us hear him. After describing how the tree is felled, due regard being taken "to discern when it is ready to fall, lest it might light upon their own pates," he then goes on:

> The tree being down and prepared, they take one of the oldest of their company, whose teeth could not be used for the cutting (or as others say, they constrain some strange Beaver whom they meet withal) to fall flat on his back (as before you have heard the Badgers do) and upon his belly lade they all their timber, which they so ingeniously work and fasten into the compasse of his legs that it may not fall, and so the residue by the tail draw him to the water side; . . . and this seemeth to be true, because there have been some such taken, that had no hair on their backs.

This seems pretty hard treatment of a stranger. And so Topsel thought, for he adds—"which [hairlessness] being espied by the hunters, in pity of their slavery, or bondage, they have let them go away free." Thus it is seen that there is more kindness in the hearts of the "cruel hunters" than in those of the "kindly beavers."

This account of Topsel's is from the 1658 edition of his book, on the title page of which his name has but one "l" instead of the two generally used. However, the first edition appeared in 1607. This I have not seen, but it surely contains the accounts quoted. But a scant half dozen years later (1613), Michael Drayton published his poem, "Poly-olbion." In this he described nearly everything in Great Britain, including the animals. Concerning the use of the beaver as a wood-wagon I quote from the "Sixt Song" (pp. 88–89) of Part I of his work, as reproduced in facsimile from the Spenser Society's reprint of the 1622 edition.

> A forraging he goes to Groues or bushes nie,
> And with his teeth cuts downe his Timber: which laid-by,
> He turnes him on his back, his belly laid abroad,
> When with what he hath got, the others do him load,
> Till lastlie by the weight, his burthen hee have found.
> Then with his mightie taile his carriage having bound
> As Carters doe with ropes, in his sharpe teeth hee grip't
> Some stronger stick: from which the lesser branches stript,

He takes it in the midst; at both the ends, the rest
Hard holding with their fangs, unto the labour prest,
Going backward, tow'rds their home the loaded carriage led,
From whom, those first heere borne, were taught the useful Sled.

Here are introduced two new and interesting helps in wood hauling. The wood is evidently loaded crosswise of the "wagon," since his tail is used to hold it on (recall how the marmot holds the hay from slipping), just how is not made clear. But clear is the method of attaching the motive power. The loaded beaver holds crosswise in his mouth a strong and clean stick of wood, the other beavers lay hold of each end of this and backing away slowly drag their burdened fellow. This draws the beaver with and not against the slant of the hair, as all the other previous narrations have had their animals do.

Bishop Erich Pontoppidan, of Bergen in Norway, published in Danish at Copenhagen, in 1752, an interesting work, the English version of which is "The Natural History of Norway" (London, 1755). He and his book are often condemned for relating such stories as that now quoted:

> To transport these building materials to the spot, he [the Beaver] uses a most surprising address, as I am assured by many who have been witness. It is this. A number are employed on this work together; and one will suffer himself to be used as a cart, which the others, like horses, take hold of, fastening on him by the neck, and dragging him along; for this purpose he first throws himself on his back, with his legs up, between which they lay their already fitted and prepared timber; and in that manner bring it to the spot where the building is to be erected, one load after the other; but this always costs the first a bare back, for it takes all the hair off.

Just how the motive power beavers "fasten on him by the neck" is not clear, but it is significant that the beaver who serves as a cart has the going made as easy for him as possible. Pontoppidan and Drayton, of all the authors quoted, are the only ones who have the animals dragged with the slant of the hair. The others have their animal carts pulled against the lie of the hair, thus greatly increasing the friction of the animal's back on the ground and hence the difficulties of transport.

These accounts from the old books may of course be set down as fables, each probably having its origin in its predecessor, the ultimate source being Pliny's story. Where *he* got his account, no one can say.

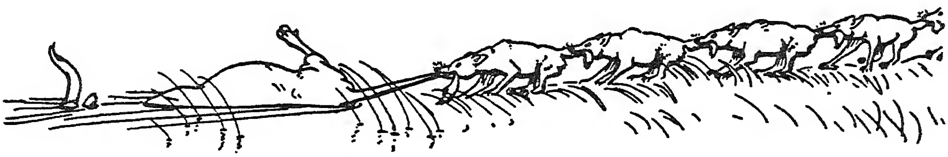
And now, having concluded the marmot, badger and beaver tail-dragging stories, may I drag in as a tail-section another interesting tale from old Topsel—that of wolves practising something of the same habit but on another animal. He writes thus on his page 573:

> But if they [the wolves] chance to see a Beast in the water, or in the marsh, encombred with mire, they come round about him, stopping up all the passages where he should come out, baying at him, and threatning him, so as the poor distressed Ox plungeth himself many times over head and ears, or at the least wise they so vex him in the mire, that they never suffer him to come out alive. At last when they perceive him to be dead and clean without life by suffocation; it is notable to observe their singular subtilty to draw him out of the mire, whereby they may eat him; for one of them goeth in, and taketh the Beast by the tail, who draweth him with all the power he can, for wit without strength may better kill a live Beast, then remove a dead one out of the mire: therefore he looketh behinde him and calleth for more help, then presently another of the Wolfs taketh that first Wolfs tail in his mouth, and a third Wolf the seconds, a fourth the thirds, a fifth the fourths, and so forward, encreasing their strength, until they have pulled the Beast out into the dry land: whereby you may see, how they torment and stretch their own bodies, biting their tails mutually, pinching and straining every joynt until they have compassed their desire.

The question, as to who or what was the source of Topsel's story, was solved by going to Gesner, where on page 724

of his "De Quadrupedibus" (Vol. I of the "Historiae," 1551) is found the account in Renaissance Latin.

To illustrate this account, which he quotes in his "Mammals of Illinois and Wisconsin," Mr. Charles B. Cory has had a figure drawn, and this I append as a fitting tailpiece to this tale in which tails form such a prominent feature in this account of animal tractors.



HOW THE WOLVES DRAG FROM A SWAMP A DEAD OX THAT THEY MAY DEVOUR HIM. FIGURE DRAWN TO ILLUSTRATE TOPSEL'S ACCOUNT. (AFTER CORY, 1912.)

MUNICIPAL HISTORY FROM ANATOMICAL RECORDS

By Dr. W. MONTAGUE COBB

ANATOMICAL LABORATORIES OF WESTERN RESERVE UNIVERSITY AND HOWARD UNIVERSITY

INTRODUCTION

THE tombs of the ancient dead with their human remains, accessories for future comfort and records vividly portray the culture of the times. It is almost startling to find that in a few institutions to-day unique catacombs of our contemporaries reflect in precisely similar manner the significant events of our own time.

Since 1911, all the cadavera received in the Anatomical Laboratory of Western Reserve University have been carefully documented by Professor T. Wingate Todd and their records and skeletal remains preserved in the Hamann Museum. Late in 1931, this collection included 2,139 individuals, of whom 82 per cent. were males and 18 per cent. females. Two thirds of the males and slightly more than half of the females were White; the remainder were American Negroes, with occasional Chinese, Mexicans and Indians. To determine the character of the population sample thus represented, the data from the death certificates and, in many cases, the clinical histories of these individuals were analyzed in the light of known historical and sociological facts. It was found that although this laboratory population constitutes but 1 per cent. of the total dead of the city of Cleveland for the twenty-one-year period during which it was assembled, it reflects to a remarkable degree the major concurrent social and industrial developments. This is because most of the cadavera were conscripted as unclaimed dead from the least stable elements of marginal economic groups in the living population, chiefly foreign-born Whites, their immediate descendants and American Negroes, people who with few exceptions were without skilled occupations.

SOCIO-ECONOMIC STATUS

Although there were twelve times more White than Negro deaths, only twice as many Whites arrived at the laboratory or relatively six times more of the Negro dead. Between 1911 and 1915 a large majority of the entering cadavera were White. Since 1915, there has been a practically uninterrupted in-

crease in the percentage of Negroes, until in 1930 and 1931 their number exceeded that of the Whites.[1] The Negro population of the city grew from 8,448 in 1910 to 34,451 in 1920 and 73,102 in 1930. The year 1915, when the Negro cadavera began to increase in relative number, marked the first major influx of Negro industrial workers from the South. The gradually rising percentage of Negro cadavera during the ensuing ten years may be accounted for simply by the population increase and low economic position of the Negro in the city. In the last five years, however, the proportion of Negro to White cadavera has been much greater than would be expected from the number of city deaths. Green's recent book[2] shows that in the recent depression the Negro has been by far the hardest hit of any Cleveland group.

Birthplace

The birthplaces of 1,177 or 55.6 per cent. of the cadavera are known. Of these 723 are White, 52.6 per cent. of all the White, and 453 are Negro, 61.1 per cent. of that group. There is internal evidence that the picture presented by the sample of known birthplace is true also for the entire lot, with a bias toward more foreign-born Whites. The table gives the origin by country of the foreign-born and by state of the native cadavera. Sixty per cent. of the Whites are of European birth, while only six individuals or 1 per cent. of the Negroes were born in foreign lands.

Foreign-born Whites: Twenty-five European countries are represented. The map in Fig. 1 shows more directly than the table the regional concentration of the birthplaces. The population

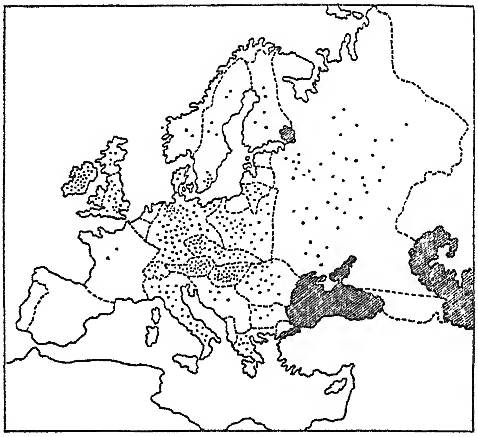


Fig. 1. Birthplaces of foreign-born whites in laboratory population, 1911–1931.

movements known as the "old" and "new" immigrations were both responsible for the presence in this country of these individuals whose common occupational level indicates a fairly homogeneous social stratum.

Native-born Whites: It was stated that the native Whites were principally of foreign parentage. This fact was officially recorded in only 49 instances. Fig. 2 reveals that, although the 292 known native Whites came from 21 states, the majority were born in three —Ohio, New York and Pennsylvania. When the Clevelanders, both White and Negro, who are largely children, are

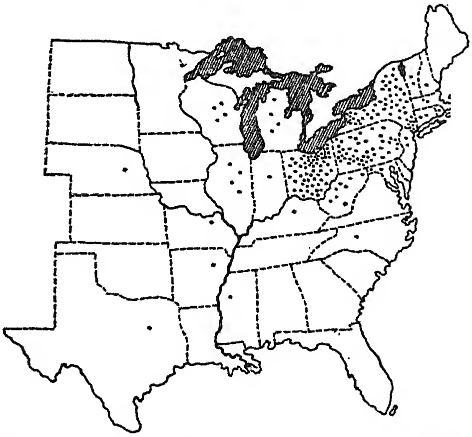


Fig. 2. Birthplaces of native-born whites in laboratory population, 1911–1931.

[1] Cleveland Division of Health, "Statistical Reports, City of Cleveland, Ohio." Annual Municipal Reports, 1916–1929.

[2] H. W. Green, "Population Characteristics by Census Tracts, Cleveland, Ohio," Plain Dealer Publishing Co., Cleveland, 1930.

ORIGINS OF SUBJECTS ACCORDING TO RACE

Foreign-born Whites			Native-born Whites			Native-born Negroes		
1.	Germany	83	1.	Ohio[e]	131	1.	Ohio[f]	76
2.	Austria	59	2.	United States	70	2.	Georgia	64
3.	Ireland	45	3.	New York	34	3.	United States	56
4.	Hungary	41	4.	Pennsylvania	21	4.	Alabama	51
5.	Czechoslovakia[a]	31	5.	West Virginia	5	5.	South Carolina	33
6.	Russia	30	6.	Illinois	5	6.	Tennessee	26
7.	Poland	28	7.	Michigan	5	7.	Virginia	24
8.	Great Britain[b]	22	8.	Wisconsin	4	8.	Kentucky	20
9.	Italy	20	9.	Tennessee	3	9.	Mississippi	18
10.	Canada[c]	12	10.	Massachusetts	2	10.	North Carolina	14
11.	Rumania	9	11.	Connecticut	1	11.	Arkansas	12
12.	Finland	8	12.	Rhode Island	1	12.	Maryland	6
13.	Greece	7	13.	Maryland	1	13.	Missouri	5
14.	Sweden	5	14.	North Carolina	1	14.	Indiana	5
15.	Jugoslavia[d]	5	15.	Texas	1	15.	Pennsylvania	5
16.	Switzerland	4	16.	Mississippi	1	16.	Florida	4
17.	Lithuania	4	17.	Kentucky	1	17.	Texas	4
18.	Bulgaria	4	18.	Missouri	1	18.	New York	4
19.	Mexico	4	19.	Indiana	1	19.	Kansas	3
20.	France	3	20.	Nebraska	1	20.	Michigan	3
21.	Denmark	2	21.	Arkansas	1	21.	Illinois	2
22.	Norway	1	22.	Washington	1	22.	Louisiana	2
23.	Holland	1		Total	292	23.	West Virginia	2
24.	Latvia	1		Foreign-born Negroes		24.	District of Columbia	2
25.	India	1	1.	Canada	3	25.	Massachusetts	2
26.	Europe	1	2.	West Indies	2	26.	Nebraska	2
	Total	431	3.	Abyssinia	1	27.	Minnesota	1
				Total	6	28.	New Jersey	1
							Total	447
							Additional	
						1.	China	1

Total White	Total Negro	Total Yellow-Brown	Grand Total
723	453	1	1,177

[a] Czechoslovakia incl. 23 Bohemians
[b] Great Britain " 6 Scots, 2 Welsh, 1 Manx
[c] Canada " 1 Newfoundlander
[d] Jugoslavia incl. 2 Serbs, 1 Croat
[e] Ohio " 73 Clevelanders
[f] Ohio " 54 Clevelanders

subtracted from Ohio's total, this state still ranks first as a native birthplace. This fact must be attributed in part to the influence of the location of the laboratory. New York and Pennsylvania are precisely the states in which the people of the "new" immigration settled most thickly. Moreover, Carpenter[3] showed that beside the "new" groups, New York and Pennsylvania had in 1920 the highest percentages of Germans and English as well as many Irish who were particularly susceptible to urbanization.

[3] N. Carpenter, "Immigrants and their Children," Census Monograph, VII. U. S. Gov't. Printing Office, Washington, D. C., 1927.

Thus, among the foreign-born of the three states that have supplied most of the native Whites, there have been large contingents of both the "old" and "new" immigrations. The age distribution of the natives (Fig. 4) and the small series known to be of foreign parentage indicate that these native-born came more from the "old" stock than the "new." When the low economic status of these native Whites is considered, the regional concentration of their birthplaces is strong though indirect evidence of their foreign ancestry.

Negroes: An entirely different distribution appears for the birthplaces of the

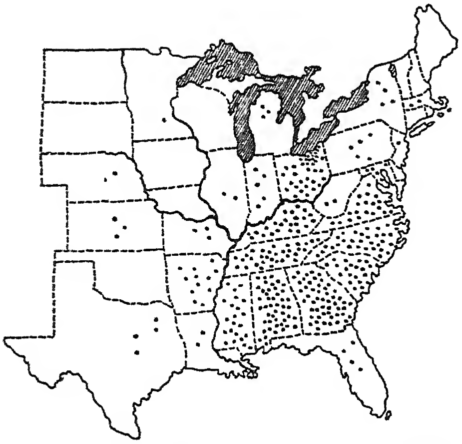


FIG. 3. BIRTHPLACES OF NEGROES IN LABORATORY POPULATION, 1911–1931.

Negro cadavera (Fig. 3). These have come from 27 states and in representative numbers from a much wider territory than the White natives. A heavy majority, however, were born in Georgia, Alabama and South Carolina, the greatest centers of Negro population. Many came also from Tennessee, Virginia, Kentucky, Mississippi, North Carolina and Arkansas.

Most of these Negroes were part of the familiar northward industrial migration already mentioned. Kennedy[4] cites the increase in the Negro population of Ohio between 1910 and 1920 according to nativity from six southern states. As the industrial centers were the goals of the migrants, it is very probable that Cleveland received her share of these people in the same proportions. Certainly it is remarkable how nearly the same relative representation of these states occurs in the small laboratory series.

Still another movement is hinted by a few cadavera. As the "new" immigrant succeeded the "old" and the Negro followed the "new," so after the Negro has come the Mexican, who in the South has filled many jobs left vacant by the Negro. Though at present the Mexican has reached northern industry only in small numbers, four of his countrymen rest in our catacombs.

[4] L. V. Kennedy, "The Negro Peasant Turns Cityward," Columbia Univ. Press, N. Y., 1930.

AGE

The mortality curve of the cadaver population (Fig. 4) exhibits a peak in middle age. The median age of the collection is 45 years. Comparison of the curves of the component groups is illuminating. We note a distinctly old age curve for the "old" immigrants (median age 58 years), a middle age curve for the "new" immigrants (median age 42 years) and a still earlier one for the Negroes (median age 37 years). The native Whites have a less concentrated distribution (median age 45 years).

Immigrants as a class are composed of the active age groups, containing very few children and old people. Hence, our anatomical curves must be interpreted with consideration for three factors—economic level, characteristics of the immigration involved and the date of collection of the material. Hence the skeletal collection presents evidence of three mass movements and of the existing economic depression.

MIGRATIONS

Roughly about two hundred years ago a great colonization and national development program attracted settlers of the "old" immigration, who came from

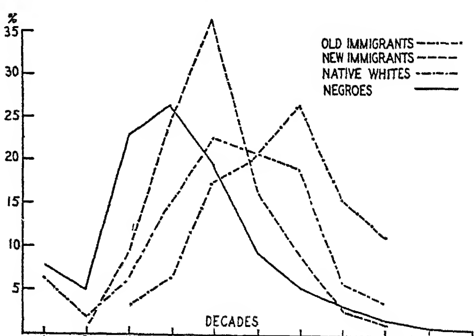


FIG. 4. PERCENTAGE DISTRIBUTION OF STOCKS IN LABORATORY POPULATION BY AGE IN DECADES.

the British Isles, Germany and the Scandinavian countries. Since this immigration reached its peak in about 1880, thirty years before the collection was started, we should expect the cadavera of this stock to be the oldest, as they are.

With the beginning of a new era of accelerated industrial progress toward the close of the last century, hordes of "new" immigrants from eastern, central and southern Europe were called to this country to supply the unskilled divisions of labor. This movement was abruptly stopped by the war and later permanently restricted by law, thousands of the new-comers returning to their European homes. The "new" immigration reached its peak and sudden termination soon after our collection was begun, but as many of these people had come over in the two preceding decades, most of our "new" immigrants among the cadavera approximate middle age.

To fill the demands for crude labor created by the war and the reduced European supply, the Negro swarmed northward. The Negro migration occurred in the midst of the years of collection so that the truest picture of all would be anticipated in this group. Our records of duration of residence in Cleveland show that many of the first arriving of these Negroes are in our catacombs. The unusually early age peak of the Negro curve shows economic slaughter at its height.[5] Since there are few aged among the migrants and the survivors have not yet had time to grow old, there is no old age component in the Negro curve.

Causes of Death

Fig. 5, showing the highest seven causes of death in the cadavera, reveals that the diseases of poverty and exposure—tuberculosis, pneumonia and ex-

[5] T. W. Todd, "Skeletal Records of Mortality," Scientific Monthly, 24: 481–496, 1927.

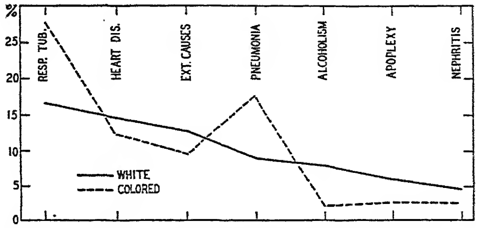


Fig. 5. Seven highest causes of death in cadavera, percentages of white and Negro.

ternal causes—have produced more casualties in this group than in the general population. Particularly is this true for the Negro cadavera among whom the respiratory diseases take the same precedence as in general Negro mortality.[6]

According to Rosenau, "The prevention of tuberculosis has become a sociological problem." The high incidence of tuberculosis among our cadavera of both races is evidence of the economic stratum in which these persons lived, confirming deductions from occupational data and from the fact that they were unclaimed.

There is a close similarity between this cadaver population and Pearl's population of persons necropsied at Johns Hopkins,[7,8] in respect to the age distribution by race and sex in their general populations. This similarity naturally follows the common social origin of the material.

Forecast of the Future

The population of Cleveland may now be said to be of an established and fairly stable character and, unless unforeseen social movements of great magnitude occur, the cadavera of the future will be

[6] M. Gover and E. Sydenstricker, "Mortality among Negroes in the United States," *Public Health Bulletin*, No. 174, 1928.

[7] R. Pearl and A. Bacon, "Statistical Characteristics of a Population Composed of Necropsied Persons," *Arch. Path. and Lab. Med.*, 1: 329–347, 1926.

[8] R. Pearl, "The Racial Origin of Almshouse Paupers in the United States," *Science*, 60: 394–397, 1924.

conscripted in the main from the elements that are in and about Cleveland to-day. Green's volume[9] affords an authentic source of information on the economic status of these several groups. His data suggest that the laboratory may expect to receive in the next ten years or so a minority of White cadavera of about 40 per cent. or less. The foreign-born should continue to constitute a large proportion of these but should be more of "new" than "old" immigrant stock for the unabsorbed remnants of the latter are fast disappearing. With the passage of time even the "new" foreign-born will come in progressively older age groups, just as our "old" immigrants have done, and then diminish in number as our "old" immigrants are now doing. The replacements in the younger age groups will be largely from natives of foreign or mixed parentage. The bulk of the Negro majority will probably continue to be of southern nativity and will tend to present a more normal age distribution. More females and young people may be expected. It is unlikely that the list of principal causes of death will undergo significant change.

[9] *Loc. cit.*

Summary

The characteristics of the cadaver population, comprising 2,139 persons in the Laboratory of Anatomy of Western Reserve University, namely, its conscription from the unclaimed dead of the city, its age at death, occupational level, mortality record, and racial composition, demonstrate that as a whole it is from a low economic stratum of society subjected to more than the usual hazards of modern life.

Though this cadaver population constitutes but 1 per cent. of the total dead of the city for the years during which it has been assembled, it reflects surprisingly closely the significant economic developments in the history of Cleveland during that period and it affords an enlightening insight into the social structure of modern American civilization.

Analysis of the factors determining the character of the present laboratory population permits certain general predictions concerning its future composition.

THE NORMAL CRIMINAL

By Dr. J. G. WILSON

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There are many persons who believe that if a man is in prison, this, in itself, is evidence that he is an abnormal individual. On first thought, this seems to be a logical conclusion. Whenever a man gets into serious difficulty, especially if such difficulty shows unusually obnoxious behavior, his friends invariably come to his rescue with an excuse couched in such terms as these: "I have known this man a long time. I can not conceive how he can have done such a thing unless he is crazy"; or, "I've known him since he was a boy, and he could not have done this if he had been in his right mind." The fault in this opinion rests largely in the fact that we do not know what a normal or average man is. What do we mean by the term "normal"?

Broadly speaking, this word has three shades of meaning: the pathological, the normative and the statistical. If a man is sick he is not well, and therefore in the pathological sense he is abnormal. If a primary school does not come up to the standards of education set by the normal schools, it is abnormal in the normative sense. If a man is only four feet two inches high, he is abnormal in the statistical sense because he falls outside the normal deviations from the average so far as height is concerned. It is in this third or statistical sense that the term "normality" in relation to prisoners will be discussed.

First, let us consider the average man from the physical standpoint. Among 7,891 prisoners coming under observation in a large correctional and penal system during the year 1932, we found approximately 30 per cent. suffering from disease or physical defects, which if encountered in immigrants seeking admission to the United States would have resulted in their deportation as likely to become public charges on account of their inability to earn a living.

Although physical defects and disease are probably more prevalent and more serious among the criminal than the non-criminal group, we have no absolute proof that such is the case. In this connection we should remember that medical examinations of school children in all parts of the United States invariably reveal the presence of physical defects approximating from 20 to 50 per cent., depending largely upon the general standards of sanitation and medical supervision which prevail in the communities from which they are drawn. The large number of men rejected for physical defects in the drafts for the World War also indicates that the average individual in the United States is far from being physically perfect. If we consider perfection and normality as synonymous, it is quite evident that, from the physical standpoint, there are few normal men among the general population.

Even those who regard themselves as being in the "pink of condition" make frequent excursions into the realm of abnormality. Sometimes they have gas on the stomach and intestinal upsets with attacks of vomiting and diarrhoea. Probably 25 per cent. of the general population is constipated. After undue physical exertion, one is too tired to sleep and prolonged mental concentra-

tion also produces insomnia. The average man has had warts on his fingers, ingrowing toe-nails and corns and occasional attacks of sore throat, "athlete's foot" and poison ivy. As a baby, he had the prickly heat, and as an old man he has bleary eyes and the salt rheum.

It is certain, therefore, that if "normality" is considered equivalent to bodily perfection, the "average man" is not normal. But these minor physical defects with which average men are all more or less afflicted, do not prevent the average man from taking his proper place in society and keeping up his end of the load in a respectable and decent manner.

Many otherwise average men have physical defects of a distinctly pathological and chronic nature, such as exophthalmic goiter, pulmonary tuberculosis, rheumatic affections of the joints, lumbago and even gallstones and chronic appendicitis. Nevertheless, such afflictions are not regarded by them as excuses for anti-social acts, nor do they hinder them from expending all the energy at their command to make an honest living.

As there is no such thing as a perfect body, there is likewise no perfection of temperament or character. Inherently bad characters are due to faulty integration of temperament, will and intelligence.

The instinct of self-preservation frequently manifests itself in behavior which crosses the dividing line between legal and illegal acts. Pugnacity, which is one of the manifestations of self-preservation, keeps men out of trouble as well as getting them in. Acquisitiveness, another manifestation of the instinct of self-preservation, may make a man either a bank robber or a bank president. Young children naturally take whatever they want with no thought that they are doing wrong. Man is a natural born murderer, thief and robber and must be taught the difference between mine and thine.

The instinct of propagation of the species is so strong that it is only through a combination of circumstances that a larger number of normal men and women are not prosecuted for violation of the Mann Act.

The instinct for power, or the desire for domination and self-assertion, is at the root of all social progress. It is the force which spurs great men to action. During adolescence this desire to rule manifests itself in an overbearing attitude and resistance to advice from father, mother and teacher.

These natural traits occur in what many believe is an exaggerated form in all criminals. But, as a matter of fact, how do we know that such is the case? How many perfectly successful men who have never come in contact with the law were overbearing boys, played "hooky," stole watermelons and even on occasion lifted a quarter from their father's pocket? How many men, perfectly normal in the belief of their families and friends, have had sexual experiences which, had they been detected, would have landed them in jail? Shall we say that a man is abnormal simply because he has added the experience of being in jail to his long list of other anti-social acts?

Even the greater mental defects are by no means the exclusive possession of criminals. All epileptics are not in epileptic colonies or in prison. There are certainly more feebleminded outside of institutions than inside. Chronic alcoholism, supposed to be one of the chief causes of criminal acts, exists to a large extent among men who have never come in conflict with the law.

How many queer persons there are in every family! If the family is well-to-do and at the same time possesses a modicum of pride, the eccentric old-maid aunts, hobo uncles and ne'er-do-

well brothers do not often fall into the hands of the police and, when they do, by magic means they soon fall out again. There is no such thing as a perfect family. Every family has its black sheep, but all black sheep are not led to the slaughter.

Just as it is impossible to say with certainty what constitutes the normal criminal from the standpoint of his physical and mental health, so we experience the same difficulty when we seek to evaluate those factors which go to make normal heredity, environment and education.

There have been many studies which reveal the apparently large number of feebleminded ancestors of the feebleminded; but control investigations to show the absence of feebleminded or insane in the hereditary background of the individual with normal intelligence are not very convincing.

Although we may be unable to define exactly the term "abnormal family history," we know that the hereditary factor is of great importance in mental disorders. But it is obviously impossible to define "normal heredity." Every family has its black sheep, and all families have the genes of black sheep in their blood.

What is a normal social environment? For one man it will mean one thing, for another, another. In some parts of the country the presence of churches and the absence of Sunday baseball are considered necessary for community morals, and there seems to be a rather widespread belief that a child whose parents have been divorced has thereby been subjected to an overwhelming handicap. But, how many good and successful men have played Sunday baseball when they were boys, and how many broken homes are there where the children have made good in after life and how many failures where there was congenial parenthood! We know about the broken homes of criminals, but we do not know about the number of broken homes in families who have not contributed their quota to criminal institutions.

What is a normal family income? Twelve hundred dollars a year might be considered normal in some environments, and totally inadequate in others. Five thousand, ten thousand, fifteen thousand, twenty-five thousand, could all fall into the inadequate income class, depending upon the particular circumstances in the case.

What is a normal education? Moss and Hunt in their book, "Foundations of Abnormal Psychology," state that the latest statistics show that the average person does not even finish elementary school and that if a person's education is equivalent to the sixth grade child, he is just about average.

R. A. McGee, the educational director at the United States Northeastern Penitentiary, made a study of the previous education of the first eight hundred prisoners received at that institution. He found that their education ranged from illiteracy to postgraduate degrees. Nine per cent. were totally illiterate, 20 per cent. tested below the beginning of the fourth grade, 30 per cent. tested grades equivalent to the eighth grade or better, 20 per cent. above second year high school and approximately 15 per cent. had some college work. Although there is a wide range of educational attainments in this group, the medium educational grade status was the fourth month of the sixth grade, which coincides almost exactly with the figures mentioned by Moss and Hunt as the average for the general population.

In the statistical sense we conclude then that convicts are not recruited exclusively from the abnormal groups and that among them there are many who are just as normal as the average man in respect to economic status, education, mentality and health.

What kind of crimes do normal persons commit? The answer is; they may commit almost any kind of crime. Just as normal men are distributed throughout the legitimate occupations, so they are scattered through the illegitimate.

Broadly speaking, crimes can be divided into those where violence is or may be necessary for their consummation, and those where dishonesty without violence is the essential factor. The contention that the average or normal individual runs the gamut of all the subdivisions under these two general headings is supported by a study of 1,340 prisoners selected at random from the Federal Penitentiaries at Lewisburg, Pennsylvania, and Atlanta, Georgia (Atlanta 767, Lewisburg 573). The crimes of these prisoners ran all the way from rape to larceny, and included a fair sampling of every federal law violation serious enough to be called a penitentiary offense.

In this study we found that the crimes of exactly one half were committed by persons who, in the psychiatric classification, fell within the normal group. This included those committing both crimes of violence and crimes of dishonesty, but separating the two, we found that the normal group was more inclined to crimes of dishonesty than to crimes of violence, the proportion being 51.7 per cent. of the former to 37.5 per cent. of the latter.

Twenty-nine per cent. of crimes of violence were committed by persons with an intelligent quotient under 80 and 21 per cent. of such crimes were perpetrated by persons who fell into the general psychopathic group, under which are included not only the frankly insane, but also the psychopathic personalities and epileptics.

Thus it will be seen that although the normal criminal runs the whole gamut of the crime category, he is less prone to commit crimes of violence than the mentally abnormal; but aside from this, we find that when the occasion arises he will do practically anything that the feebleminded and the psychopathic will do.

His technique may differ, but he aims at the same goal. It would appear therefore that the question of normality or abnormality does not enter into guilt or innocence, responsibility or irresponsibility, but rather into the form of treatment which should be accorded individual violators of the law.

NATIONALITY OF NOBEL PRIZE WINNERS

By Professor HARRISON HALE

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AMONG those of the nineteenth century whose lives still influence widely our life to-day, few are more noteworthy than Alfred Bernhard Nobel. He was a chemist and an inventor, having taken out 355 patents in many different countries, but his interests were far-reaching. The practical applications of science and of business were in him combined with an unquenchable idealism.

Jokingly called "Europe's richest vagabond," Nobel was born in one country in Europe, left there at the age of nine, never to return except for periods of short duration, lived in at least five other European countries, besides a student residence in the United States. At his death the courts had to decide his legal residence; they chose Sweden, the country of his birth.

Born at Stockholm on October 21, 1833, he died on December 10, 1896, at San Remo, Italy. A year before in his will, signed at the Swedish Club in Paris, he made provision for the five prizes which now bear his name. In part this will reads:

> The prizes for physics and chemistry shall be allotted by the Swedish Academy of Sciences; those for achievements in the realm of physics or medicine by the Karolinska Institute in Stockholm; those for literature by the Stockholm Academy, and those for the promoters of peace by a committee of five persons to be selected by the Norwegian Storthing. It is my express wish that the prizes should be distributed without any regard to nationality, so that the prize may be awarded in all cases to the most deserving, whether he be a Scandinavian or not.

Many details had to be arranged in carrying out the provisions of this will, so that the first awards were not made until 1901. With some exceptions, awards have been made in each field every year. Explosives and petroleum were the basis of the fortune given the Nobel Foundation, estimated in 1901 at approximately eight million dollars. The amount of each prize varies year by year, from $30,802 in 1923 to $46,420 in 1931. More than four million dollars have been so distributed.

The financial view-point is not the most important. Writing in the SCIENTIFIC MONTHLY for January, 1931, Dr. Hans Zinsser, of the Harvard Medical School, says: "The establishment of the Nobel Prizes has had a far greater significance than the tangible rewards accruing to recipients. It has created international public recognition."

Assuming that the prizes have been awarded in accordance with the terms of the will "without any regard to nationality" so far as humanly possible, the study of the nationality of the winners for a third of a century furnishes at least to some extent a measure of the success of various nations in these fields. No one could claim this measure as infallible or even entirely accurate, but it is certainly suggestive as well as most interesting.

Occasionally a classification is difficult; thus Madame Curie, though born in Poland, is listed as French, because her work was done in France, and Einstein is classed as German, since he was a professor at Berlin in 1922 when the award was made. This study is not made in a spirit of narrow nationalism, rather of internationalism, as all true science, literature and peace are international.

Had awards been made in each field every year from 1901 through 1934, the

total would have been 170. The "List of Nobel Laureates," published in Stockholm in 1934 by the Nobel Foundation, records 141 awards from 1901 to 1933. Four additional awards have been made in 1934, giving a total of 144. In thirty of these, the award was a joint one, usually to two persons, in two cases to three; thus 177 persons have been so honored. The only person twice receiving an award was Madame Marie Curie, who shared the physics prize with her husband and with Henri Becquerel in 1903, and after her husband's death she alone was given the prize in chemistry in 1911. In Table I, joint awards to three are counted as one third, other joint awards made to two persons are counted as one half each.

TABLE I
NOBEL PRIZE WINNERS
1901–34

Country	Physics	Chemistry	Physiology Medicine	Literature	Peace	Awards 1901–18	Total
Germany	10	13	5	5	1	20	34
England	6	4½	3	3	2½	9	19
France	4	3	3½	4½	3½	11½	18½
United States	2½	3	4	1	5½	5	16
Sweden	2	2½	1	3	2	5½	10½
Switzerland	1	1	1	1	2½	4½	6½
Holland	3	1	1½	.....	½	4½	6
Denmark	1	.....	3	1	½	2½	5½
Austria	.....	1	2	.....	1½	2½	4½
Belgium	.....	.....	1	1	2½	3½	4½
Norway	.....	.....	.....	3	1½	1	4½
Italy	½	.....	½	3	½	2½	4½
India	1	.....	.....	1	.....	1	2
Poland	.....	.....	.....	2	.....	1	2
Russia	.....	.....	1	1	.....	1	2
Spain	.....	.....	½	1½	.....	1	2
Canada	.....	.....	1	.....	.....	.....	1
Ireland	.....	.....	.....	1	.....	.....	1
International	.....	.....	.....	.	1	1	1
Total	31	29	28	32	25	77	145
Distribution	10	8	14	15	13	16	18

Eighteen nations are represented; three times the prize in peace has been awarded to organizations. One of these, the Institute of International Law at Ghent, receiving the prize in 1904, is classed as Belgian; the Permanent International Peace Bureau at Berne in 1910 is placed as Swiss; but the International Red Cross of Geneva in 1917 is best called international.

Only one woman has received an award in the sciences and she won two, Marie Curie of Paris being honored both in physics and in chemistry. No woman has won the prize in physiology and medicine. Three women have attained distinction in literature: Selma Lagerlöf of Sweden in 1909, Grazia Deledda of Italy in 1926, and Sigrid Undset of Norway in 1928. In peace, prizes have been given to Baroness Bertha von Suttner of Austria in 1905 and to Jane Addams of Chicago, who shared the award with Dr. Butler in 1931.

An examination of the table shows the largest number of awards have been made in literature and in physics, 32 prizes out of a possible 34 being the highest. In peace only 25 prizes have been given in 34 years.

Only six countries, one third of the eighteen to whose citizens awards have been made, received a prize in each field. The United States entered this group in 1930, when the prize in literature went to Sinclair Lewis. Prizes in chemistry have gone to only eight countries, in physics to ten, with a wider distribution in the other fields.

The preeminence of Germany is quite striking, especially in the physical sciences. The awards to France are more evenly distributed. The United States is outstanding only in the number of peace prizes received. On a basis of population, the standing of the leading nations relative to that of the United States would be improved, and Sweden, Switzerland, Holland, Denmark and possibly others would outrank us.

This position may not appeal to American pride, but it is well to face

the facts. Probably distance has been a handicap to Americans, but real efforts have been made to comply with the will of the founder, and the handicap should not be overemphasized. It may be a satisfaction to Americans to know that the position of the United States is improving.

A comparison of awards made before and since the close of the world war is shown in the last two columns in Table I. It appears that England and the United States have made a relative gain, that Germany, France, Switzerland and Holland have suffered a relative loss, while Sweden maintains about the same standing. Seventy-seven prizes were listed from 1901 to 1918, and sixty-eight have been given since. Only two new nations have been added, Ireland and Canada, and these have much in common with England.

It is evident that though Germany has lost relatively since the war, her supremacy is easily maintained in both periods. England and the United States seem to be gaining on France, and England seems likely to surpass her.

At any rate, to those who care for such things it is as interesting as a big league baseball record. The habit of adjusting one's self to the standings after the prizes are announced each November might be worth while.

American Nobel Prize winners are:

Physics:

1907—Albert A. Michelson, died 1931; professor of physics, University of Chicago.

1923—Robert A. Millikan, director of physics laboratory and chairman of executive council, California Institute of Technology, Pasadena.

1927—joint award, Arthur H. Compton, professor of physics, University of Chicago.

Chemistry:

1914—Theodore William Richards, died 1928; professor of physics and director, Gibbs Memorial Laboratory, Harvard University.

1932—Irving Langmuir, research laboratory, General Electric Company, Schenectady, N. Y.

1934—Harold C. Urey, professor of chemistry, Columbia University.

Physiology and Medicine:

1912—Alexis Carrel, Rockefeller Institute for Medical Research, New York City.

1930—Karl Landsteiner, Rockefeller Institute for Medical Research, New York City.

1933—Thomas H. Morgan, professor of biology, California Institute of Technology, Pasadena.

1934—joint award, George H. Whipple, dean, University of Rochester School of Medicine and Dentistry.

joint award, George R. Minot, professor, clinical medicine, Harvard Medical School.

joint award, William P. Murphy, instructor, clinical medicine, Harvard Medical School.

Literature:

1930—Sinclair Lewis, author, New York City.

Peace:

1906—Theodore Roosevelt, died 1919; President of the United States.

1912—Elihu Root, formerly Secretary of State, U. S. A.

1919—Woodrow Wilson, died 1924; President of the United States.

1925—joint award, Charles G. Dawes, Vice-President of the United States.

1929—Frank B. Kellogg, formerly Secretary of State, U. S. A.

1931—joint award, Jane Addams, Hull House, Chicago.

joint award, Nicholas Murray Butler, president of Columbia University.

In the stimulation of worth-while endeavor in five different fields, all of the greatest importance for the welfare of mankind, the efforts of Alfred Nobel are still active and promise to be an increasing influence far into the future.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

HARNESSING SCIENTIFIC DISCOVERIES

By Dr. P. G. AGNEW

SECRETARY, AMERICAN STANDARDS ASSOCIATION

To most of us radio is the most startling triumph of the machine age—this thing that can carry the human voice to the ends of the earth—through silent space—and with the speed of light.

I am sure that it all seems to you, as it does to me, a never-ending miracle that people in far-off Australia, or that intrepid band of explorers with Admiral Byrd in the desolate region down near the South Pole, can hear the notes of an orchestra a fraction of a second sooner than the people in the rear of the concert hall itself. Just to think that each of my words is being carried to your radio set in the form of electric energy less in amount than you use in the flicker of an eyelash. Yet it is caught by your receiving set, greatly magnified, and then changed back into sound with a fidelity so great that from a few syllables you instantly recognize the speaker's voice—all in far less time than you take to wink your eye.

We are apt to think of radio as being built wholly on science that is new in the last few years. This is, however, not the case. Ninety-two years ago electromagnetic waves were transmitted over a distance of two hundred feet, and they were successfully detected even through the walls of buildings. This remarkable experiment was done by one of the great men of American science, Joseph Henry, who later became the first secretary of the Smithsonian Institution in Washington.

Henry did this famous experiment on the campus of Princeton University, years before the famous gold-rush of the Forty-Niners. In another one of his remarkable experiments, he was able to magnetize a needle by induction from a lightning stroke eight miles distant.

He of course did not call it radio—that is a word which had not yet been invented.

During the same period Michael Faraday, in England, carried out a long series of world-famous experiments. One of his results was to show that in ordinary electric circuits the power travels chiefly in the space surrounding the wires instead of within the wires themselves. This was before our civil war, and at the time when the ox-cart was an important means of transportation.

Sixty years ago one of the great minds of the nineteenth century, Maxwell, showed that electromagnetic energy travels through space in the form of waves, and he showed many of the properties of these waves. One of these was that they travel with the velocity of light—a velocity great enough to travel round the earth seven times in a single second. He showed that these waves would behave like light waves, and that light itself consists of very short electromagnetic waves. Maxwell discovered all this by mathematical theory, and his work, like Newton's discovery of the law of gravitation, constitutes one of the great triumphs of the human mind.

Maxwell's work waited many years to be verified by laboratory experiments by a young German scientist, Heinrich Hertz, by name. By 1888 Hertz had not

only proved Maxwell's theories to be right, but in doing so had been able, for the first time, to set up a radio sending station. At least that is what we would now call it, for he was able not only to send out the waves, but to control their frequency or wave length.

The following year Sir Oliver Lodge succeeded in setting up a radio receiving station. It was the forerunner of the radio set to which you are now listening, though to the eyes of most of us the two would have no resemblance to each other. Lodge was soon able to give a public demonstration and by 1897 had patented the use of "tuning coils," which were the forerunner of the dial on your own radio set which you use to select the station to which you are listening.

In all this earlier history we see how slowly the developments came. There were time-lags of forty and sixty and ninety years between the beginnings of the scientific principles underlying the radio art and its practical adaptation to everyday use. Yet we have seen that by 1900 things had begun to move faster, and since then they have moved very much faster indeed. This has been especially true during and since the war. This reduction of time-lag in getting science into use is a matter of great human interest and significance. I shall refer to it again.

On Christmas eve in 1906, Fessenden —a great pioneer who was in many ways ahead of his time—actually succeeded in broadcasting a program. The following year he was able, for the first time, to transmit the human voice across the Atlantic Ocean.

All these things were accomplished without the use of electron vacuum tubes which are now essential to both the sending station and the receiving set. These tubes also have a long history. The principle upon which they operate goes back to early work of Edison's half a century ago. In fact, for many years it was known as the Edison effect. The tubes depend for their action on the control of the motion of electrons—those inconceivably small particles of electricity of which the very atoms of matter are made up.

The radio tube was put into workable form by De Forest in 1907, and it was greatly improved by Langmuir just before the war. (It is interesting to note that De Forest was unable to sell his patent and let it lapse rather than pay $25.00 for its renewal.)

Great popular interest in "wireless telegraphy" was created by the use of the "S O S" at the time of the sinking of the Titanic in 1912 and in other great marine disasters.

Yet a far greater interest was to come with the advent of broadcasting, which made it possible for millions of people to have the truly thrilling experience of bringing human voices out of the air by merely twisting a dial.

Present-day broadcasting was started by Conrad on November 2, 1920, with the opening of station KDKA, the first broadcast being the election of President Harding.

From then on the response of the public to this dramatic new means of communication was unprecedentedly great and rapid. How great the response was is well shown by the quickness with which this new medium of communication came into use in political campaigns. The radio played a major part in the campaign for the presidency in 1924, when the conventions of the principal parties were broadcast. Who does not remember the oft-repeated question put by Senator Walsh, the chairman of the Democratic convention: "For what purpose does the gentleman arise?"

The imagination of the country was fired by this new medium, and radio quickly swept into popular favor the country over. By 1928 it had easily

become the principal battle ground in national political campaigns.

This great popular interest brought about extremely rapid developments in the radio art, both technically and commercially. Among these were such important steps as the loud-speaker—the self-contained set—complete electric operation, which did away with batteries—and single dial tuning. Scores of other improvements followed each other in remarkably quick succession.

It is doubtful if the speed with which these many developments came and were adapted into everyday use has ever been equaled in any other field. We have seen how these advances in the underlying sciences upon which radio is based, slow in the early stages marked by the discoveries of Henry, Faraday, Maxwell and other pioneers, have come with increasing rapidity down to the present time.

It would be interesting, if we had the time, to trace the advances in other sciences, the results of which have come into everyday use. We should see the same increasing rapidly in the growth of the science and in its everyday use.

The process of mercerizing cotton was discovered by Mercer ninety years ago, but nearly all the development, and its introduction into everyday use, has come within our own time.

It is only twenty years ago that vitamins were discovered—slightly more than a decade since the discovery of the sunshine vitamin—yet every intelligent school child to-day knows the meaning of vitamins, and every dietitian, every country doctor is prescribing them.

No longer ago than 1924 the city of Detroit found that thirty-six out of every hundred of its school children were afflicted with goiter. In the short space of seven years this was reduced from thirty-six to only two in a hundred. This was accomplished by the simple process of adding a minute amount of iodine to the table salt sold in the region. As a result thousands of the school children of Michigan, present and future, have been saved from feeble-mindedness.

Among the numerous fields in which discovery and use have come with increasing rapidity, especially during our own time, have been the electric light, the telephone, the airplane, the moving picture.

In fact, the speeding up of scientific and technical research and the parallel speeding up in the process of putting the results into practical use have largely come about within our own lives. It has come to such a stage that many of our more progressive industries do their scientific research to order, so that they may meet present and future needs. This also has come about almost entirely within a single generation.

One of the important ways by which scientific developments quickly find their way into use is through standardization. When well done, this means to find out the best way of making a thing or the best way of doing a job, and then systematically making the thing or doing the job that way. This generally means the use of the results of scientific research and it often means new researches. Standardization is a cooperative job. It is carried out by companies and by groups, such as trade associations, technical societies and government departments, and also on a national scale. The American Standards Association is the national clearing house for the standards movement.

As we have seen in the case of radio and in other fields, scientific developments have been coming with constantly increasing rapidity. Why is this? And is it or is it not to our advantage as human beings? Science is playing a constantly increasing part in our lives. This, I believe, is bound to continue and to do so with increasing rapidity. In the first place there are more and more

people working in science and in applying it to our everyday life. Then, too, as we have seen in radio, more and better means are continually becoming available to do the work. It is like having a modern machine shop available to do a job instead of attempting to do it with a monkey wrench and a screw driver, as in earlier days.

But I think the most important reason is the attitude of people toward science. It is immensely significant that they look upon scientific methods with increasing sympathy and understanding. This is true both of executives in industry and of people in all walks of life. All this means that the machine age is continuing to increase its sway. Some people look upon this with alarm. I do not. I am sure that most people who have thought about the matter deeply take the view that through science lies the road to better ways of living and to the "more abundant life" for all of us.

PAINTING THE HILLS GREEN

By B. Y. MORRISON

PRINCIPAL HORTICULTURIST IN CHARGE, DIVISION OF PLANT EXPLORATION AND INTRODUCTION, BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE

In the literature of many peoples, the idea of green hills clad with forests or with pastures, but in any case luxuriant and verdant, has become almost a symbol of happiness and well-being; and, like many poetic symbols, contains much more of fact than the casual reader might believe. In lands where the hills are not green, what does one find? Either hills or mountains that stand in the stark nakedness of their rock formations or the sorrier sight of barren earth, washing away year by year until the rock skeleton is revealed. This latter process may be slow or swift, but in its progress what happens? Essentially a loss of soil and a dissipation of the natural water supplies of the country. All the richer surface soils are carried off in the floods that fill the water courses until the country is only a mass of fissures and ravines in the poorest soils that can support neither plant nor animal life, and the water that should be slowly available is lost almost immediately.

In many cases man has contributed largely to this condition by deforestation, overgrazing, lack of adequate fire protection or poor cultural practises, all of which, different as they are in themselves, have the same basic menace, the destruction of the richer surface soils in which most plant life exists. Erosion is not merely a recent development of intensified agriculture but a phenomenon as natural as rain or the change of seasons. Just as water seeks its own level, so also does land; but the leveling of land occurs so slowly that it is not apparent except in exaggerated cases. This erosion, continually taking place in nature without the interference of man, goes on so slowly that the rich top-soil so necessary to plant life in general is formed as rapidly as it is washed away, and the green covering of plant life remains in equilibrium.

When, however, man interferes with the surface of the land or with the vegetational cover, the process of erosion is thrown askew and the wearing away of the rich upper surface of the land proceeds at a rate far greater than its replacement. With the vegetational cover removed by overgrazing or cultivation, the soil is exposed to the driving action of the wind and the washing of water. Rivulets become torrents when the impeding vegetation is removed and the torrents rapidly eat away the rich top-

soil, leaving a barren under-stratum from which the hardiest of plants can obtain scant nourishment. It is the problem of this rapid erosion with which we are here concerned, for it takes a heavier annual toll from the farmer than the combined forces of many of our more spectacular insect pests and diseases, which are quickly recognized, while erosion does not seem harmful until it has gained such headway that the land is ruined.

No doubt all of you have seen pictures of the barren and sterile rolling landscape of northern China or heard of the disastrous floods of its rivers. These are directly attributable to erosion in its advanced stages, caused by the interference of man. The forests have been stripped from the hills; all land, even to the steepest slopes, has been cultivated and later abandoned when the top-soil had washed away. What is left? Barren land that will support almost nothing. Even now in this country we have had some foretaste of like conditions with the occasional flooding of rivers such as the Mississippi, the Ohio and the Missouri.

Fortunately, this rapid erosion can be prevented and, what is more important, the problem, though large, is nowhere near as stupendous as in a country as denuded as China. We believe that when the people are made fully aware of the dangers of rapid erosion and demonstrated the means of preventing it, sufficient cooperation will be forthcoming to save our natural heritage. Recently the Federal Government has begun, under its program of public works, the task of bringing before the public the seriousness of uncontrolled erosion. Large areas have been set aside in various parts of the country to demonstrate the means by which erosion can be prevented and the means by which the land already barren can be reclaimed. These areas have been chosen, not only because they are in themselves much in need of such help, but also because they are located in regions where erosion has done considerable damage.

Let us go into some of the causes of destructive soil erosion. In the West and Southwest overgrazing has been one of the most important factors. Live stock have been allowed to graze continuously over large areas of land without giving the vegetation an opportunity of renewing itself. The plants have died and the soil no longer supported by vegetation has been sluffed away by water and wind until millions of acres have become waste. This could have been prevented by judicious grazing. In many places our forested mountains have been denuded by over-lumbering. The remaining vegetation has become too scanty to hold back the water accumulated as snow during the winter. Instead of feeding a gradual supply of water to the lower arable valleys, the water rushes down in devastating torrents, strewing the valleys with rocky debris, eating away the soil and dissipating the water so rapidly that none is left for the dry season. Our farmers have in many cases tilled the soil of slopes so steep that the downward flow of mud is inevitable. Small depressions have been allowed to become ugly gullies ever increasing in size. The fine-grained friable soils of the semi-arid prairies have had their protective sod-covering removed for mile after mile with no attempt at strip-cropping, only to have the soil blown away by the strong desiccating winds of autumn. You all no doubt recall the dust-laden air which almost obscured the sun for several days last summer. This dust represented thousands of tons of good soil lost to the Middle West. These are only a few of the causes of excessive erosion.

The ultimate goal of all erosion control work is the establishment of a green mantle of vegetation over all surfaces of the land which, by their nature or slope, would rapidly erode should this protec-

tive covering be taken away. If the surface is at present well protected, we must see that it remains so. If the surface is already denuded and eroding, we must replace its vegetative covering as soon as possible, for the damage, once begun, spreads rapidly.

When one is faced with the problem of restoring vegetation to eroded lands to make the hills green again, what must he consider?

First, he must have a thorough knowledge of the soil conditions as they exist now, for these will limit the kind of plants to those that will survive under impoverished conditions. He must know the natural precipitation, as this will determine not only the nature but also the amount of plant life that may be expected and, finally, he must know the temperature ranges and the length of the growing season. He must study the surviving vegetation and the records of previous plant life, as they are most important, suggesting to the plantsman various other plants that usually accompany the species remaining.

Since any local flora represents the adaptation of plant life to natural soil and climatic conditions, this study will make clear the point beyond which it would be unreasonable to go. It will show which land should be returned to grass, which may be most wisely returned to forest and which must find some intermediate treatment. It will show also how much vegetation can be planned for, since plant populations are dense or sparse for very definite reasons.

In studying plants that are to be used for revegetation, the plants themselves must be carefully considered as to their structure and habit. Their roots must be considered: are they fibrous, widespreading and capable of penetration to some depth in search of food? How does the plant increase as it ages? Does it reseed itself abundantly and successfully or does it send out widely running stolons or shorter underground rhizomes? Does it bend down and root at the tips of its shoots, or does it, like a honeysuckle vine, scramble over the earth, rooting at every joint?

Again, one must know if the plant for proposed use has any other virtues than those related to the preservation of the surface soil. For the present we are concerned only with those features that relate to bird and animal life, whether in the actual production of forage for browsing, fruits and seeds for eating or mere shelter.

While it has been truly said, therefore, that any plant is a potential erosion control plant, it will be appreciated that in emergencies like our present time, the use of a rather limited choice of plants seems wise, with a very keen appreciation of the fact that each erosion study presents a particular problem that possibly may be solved once for all time or may require a continuing plan in which the first plantings will be made of the only plants possible under the existing conditions but which will make possible the later introduction of plants of greater value that could not have survived at first.

It is believed by many that the most suitable species to use in replanting an eroded area are those which grew there formerly and still are found in the neighboring region, for certainly what plant would be better fitted than one found growing in the same climate? So far, so good. But remember what has happened to the soil. It has changed completely. The sterile clay now exposed has little food for the plant. The water which once was absorbed and held for the plant now runs off. Erosion has changed the environment to stark desert conditions as far as the plant is concerned, and it can not regain a foothold. Much hardier kinds of plants must be the pioneers.

The question has been raised rather critically as to the necessity of foreign exploration for the introduction of

plants for such uses as this. Although no complete answer should be attempted at this time, there are many plants that may be cited as examples of successful introduction and naturalization, maintaining themselves and invading new territory until it is sometimes forgotten that they are not native to this country.

Among the familiar grasses that dominate parts of the country pastures, one might mention Kentucky Bluegrass, which is native to the Old World and yet carries an American name because of the success of its establishment here. Timothy, an English grass, introduced in 1720, is now one of our most widely spread pasture grasses. In recent years, perhaps the most conspicuous grass introductions have been the several crested wheat grasses from the Orient, all of which are so much more permanent than the American species of the same family that only they are being widely increased and seeded to furnish forage in land now removed from cereal cultivation.

None of these grasses are soil-binding grasses except as they cover the soil with vegetation. As an example of an introduced grass that binds soil by its spreading underground stems, mention might be made of Bermuda grass, a species so invasive as to become a weed near cultivated fields, but of greatest value in poorer soil, where it is needed only for its invasive and soil-binding qualities. Studies are now being made with various native grasses, particularly with several of the Gramma grasses and Paspalums that are known to be good forage and yet do not occur in nature in sufficient quantity to prove their ability to possess the earth.

Another introduced plant that is valuable for this work and yet a menace under too favorable conditions is the Japanese honeysuckle, which covers the ground, rooting at every joint and preventing any soil erosion while it builds up a humus layer. In too good soils and in too mild climates, its spread is too successful, so it must be held in check by planting on the poorest sites. So far, no native vine has come to our attention that approaches this Oriental plant, although various dewberries are useful for some areas.

Among the herbaceous plants that are being studied are the lespedezas, of which several Oriental species have lately had much publicity. The only feature to be stressed here is that we have many native species in this country, none of which has ever become an important forage plant.

Among the important shrubs of this country that have been used for poor soils and eroded areas are the sumachs, all of which endure the poverty-stricken conditions of the eroded areas, since they are tolerant of heat and cold, of drought and low soil fertility. Perhaps no introduced shrub can offer a conspicuous parallel, although in the Southwest a shrubby Pentzia from South Africa seems likely to become a widely established and valuable browse shrub for that country with little rainfall, high temperature and limited capacity for vegetation.

Among the trees chosen for revegetation, the one species that outnumbers all others so far is the black locust which has almost every character that an erosion plant should have—an elaborate and widely-spreading root system, a capacity for enduring poor and dry soils, and wide temperature ranges, and producing from its best forms a valuable timber.

These few examples serve to illustrate only the various types of material that the plantsman is growing for use in the erosion demonstrations now under Federal care. They represent essentially plants that will survive under particularly difficult conditions and will serve to reestablish the green cover that once was everywhere. In themselves they are

plants often of secondary value but of real value because they make safe the engineering work done on the sites and furnish a beginning for new plant populations. The problems of their production are many and varied and always there is the knowledge that there must be more seed and more seedlings than would be needed under favorable conditions; and hardier and tougher strains, for nature is no longer helpful when man attempts to make green again the hills from which the natural vegetation has been lost.

PSYCHOLOGICAL RESEARCH IN SOVIET RUSSIA[1]

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Although the Russian experiment may present a confused picture in certain political and economic ways the contribution to science, especially to psychology, is in many ways striking and original. To uproot 170 million people from their old habits and customs is indeed a vast psychological experiment in itself. It shows the wide margin of adaptability of human nature with the environmental setting. The psychological principle of substitution of one cultural trait for another has been put into effect on a large scale. For example, the excessive competition between individuals has given way to group competition and the conquest of nature and society. The profit motive has been outlawed and is considered a sin. The religious motive has been redirected from superstition, fear and "other worldliness" to a better society here and now. Simple peasants, supposedly stupid and lacking in mechanical ability, have become able scientists and engineers. One must look for the chief contributions to psychological research in the new social order and the new motivation.

As the rest of the world looks at the machine and certain aspects of science with concern, if not skepticism, the Russians believe these very forces will give them freedom. Science and the scientific method underlie their whole philosophy of life. In addition to the universities and technical schools, over 800 institutes have been established to investigate the basic problems in society and human behavior. Each institute is responsible to one of the commissariats which helps define their problems for research. This affords an intimate and workable relationship between science and government. The psychological research relates primarily to child study, learning and the conditioned reflex, aptitude and intelligence testing in industry, fatigue, collective or group psychology, prostitution and alcoholism. Necessity will always remain "the mother of invention," and so-called pure science may benefit anew by this enthusiasm for applied science in the building of socialism. Frequently it is the vastness of an experiment or its social nature which is of interest rather than the originality.

In the field of child study, for example, the Communist Party requires every factory or collective farm to have a crêche or kindergarten. There are over 6 million children in such schools. The number of teachers is inadequate,

[1] This article is based upon the author's observations in Soviet Russia during the summer of 1934.

but many are well trained in the new science of pedology or the "science of the growing organism"—a combination of psychology, medicine and education. The system is one of "moulding" rather than "unfolding" as regards their behavior in the group and as to what they think and believe. Thus in accord with Lenin's wishes the rigid ideology is imposed very early. Frequently a child knows more about Marxism and dialectical materialism than how to spell or write. The arts are widely taught, such as the theater, sculpturing, painting, and especially caricatures of capitalists, kulaks, popes and nazis—inspired by the new régime. Children are instructed about electricity, machinery and carpentry. After a group of children put a toy train together they receive a lecture on the value of collective activity. The nervous, shy or individualistic child receives special attention, and unusual abilities are encouraged. The energetic side of a child's behavior is studied by measuring the intensity of a hand movement on a bulb or recording device simultaneously with some other central tendency. These experiments reveal inner conflicts and tension. Criminals and delinquents have been studied by such methods. Elaborate physiological studies are being made to determine which toys and play activities are best, in terms of the expenditure of energy and training, for children at different ages.

The genetic development of speech and thought and the higher skills have been carefully analyzed in children. Luria and Vygotski compared young children with apes in the use of tools and in the solution of simple problems. In an experiment with 2,200 children they studied memory for words with and without the use of pictures. In 10- to 12-year-old gifted children there was a 60 per cent. increase in memorizing by using associated pictures, while the stupid ones profited little by the double stimulation. Intelligence tests are fairly widely used in the schools and factories. In one study the results showed quite naturally certain cultural influences, in that the children of more able parents and from better homes, such as in professional or other educated groups, rated higher than those of the workers. This finding was condemned by the Communist Party as petty bourgeoise and created considerable discussion!

At the Institute of Biological Medicine in Moscow, elaborate studies of mental and physical growth are being carried out on 700 pairs of identical and fraternal twins. The director, Professor Levit, received part of his training at the Rockefeller Institute in New York. The most dissimilar feature in identical twins is in the T wave of the electro cardiogram. Most of the other physiological comparisons show striking similarities. One group of twins was taught how to reproduce models by parts, while their identical twins reproduced them by wholes or with the use of imagery. Even ten months later the retest showed that those who learned with the aid of imagery were superior in reproducing models. In treating identical twins suffering from rickets—one with rays, the other without—an apparent initial improvement with the rays was later shown to be definitely harmful, especially in throwing off contagious diseases. In these ways definite controls for various kinds of training and treatment have been introduced. Studies of the inheritance of high blood pressure, diabetes and gastric ulcer have shown that these diseases may be caused by genes of poor "expressive" capacity yet dominant. For example, when relatives of patients with high blood pressure were placed in emotional situations their blood pressure on the average was raised more than in

a control group. Persons with such latent biological unfitness would therefore be placed in factory positions free from emotional strain or worry. This is preventive medicine and psychological insight of the first order. And obviously the inheritance factor has not been completely lost sight of in a society which believes fundamentally in the importance of the environment.

The movement initiated long ago by the philosopher, John Locke, that ideas are not innate but acquired has its modern culmination in the work of the distinguished physiologist Pavlov. His analysis of the learning process on the basis of conditioned reflexes and the dependence of behavior on environmental stimuli are basic in the Russian scheme of things. Pavlov, now 85 years of age, keeps a large group of research workers busy in his well-equipped new laboratory near Leningrad. In spite of his greater affection for the old order than for the new the importance of his work, in addition to a personal letter from Lenin, gives him complete freedom and adequate funds and dogs. At present he is interested in analyzing hypnosis, hysteria and the disturbance of equilibrium. He has four generations of dogs in which he is studying the inheritance of temperament (excitability and inhibition). He finds certain dogs (the same as people) are more susceptible to nervous breakdown than are others. By giving a dog food with the presentation of a circle and an electric shock with an ellipse it is possible to set up a definite positive and negative response to these stimuli. If the circle and ellipse are brought closer and closer together a point is finally reached where the dog can no longer distinguish between the two. The strain in discriminating becomes too great, and the dog has an artificial neurosis. Krasnogorski is studying nervous and difficult children by similar methods. Each week Pavlov goes to a medical clinic to analyze cases from real life on the basis of his theories. An attempt was made to reform chronic alcoholics by establishing a fear response to the taste and smell of alcohol by an accompanying electric shock. But the results were not very successful.

The human equation in industry has been especially difficult in a country being industrialized so rapidly. Misfits, inefficiency and lack of skill has been the greatest obstacle to overcome. Most young Communists want to be engineers because of the social pressure, and obviously many lack the ability. Since the state pays students to be educated there has been a strong motive for careful selection. Institutes of psychotechnics have been established to investigate such problems. Over 200 laboratories have been organized to test for special aptitudes and physical disabilities in pilots, conductors, miners and factory workers. Elaborate fatigue studies have been carried on with the aid of physiologists. Researches in job analysis and the metabolic cost of different kinds of factory work have been made. Special attention is given to the safeguarding of the health of the laborer. The physiologist Kahn, for example, spends part of the time in his laboratory in detailed analysis of nerve respiration and part of the time in the factory analyzing the relative efficiency in terms of oxygen consumption of differing ways of laying brick or building machinery.

In a society which fosters the subservience of the individual to the group and idealizes collectivism new social phenomena may be observable. Dominance or leadership in certain individuals is of special interest as well as group conformity and suggestibility. The traditional family unit has not been abolished but has given way in importance to the factory, community or farm collectives.

Human affections are just as real, but the home plays a different rôle with the state taking over many of its functions, as in the preparation of meals, education of children and recreational facilities. One consequence of the freedom of women is that mother "fixations" in the children are not so frequent. The mother has an emotional outlet through her work as well as through her children, which on the whole has been healthful for both. Students of social or cultural change would find innumerable problems to study in Soviet Russia.

With the nationality policy of the new régime and the self-determination of all minority racial and national groupings there has been an accentuation of certain differences in the use of native languages and customs. In certain isolated communities long-standing local antipathies and feuds have been eliminated. Primitive groups in Siberia and the Caucasus have been studied by ethnologists and psychologists. The more primitive groups have been given an alphabet and a literature—communistic in content, to be sure. Experiments are being tried, such as analyzing the content of the thought of backward people, educating them in advanced ways of life away from fear and superstitions or in getting gypsies to become farmers in one locality. The chief criticism of this policy relates to the extent of the freedom involved. The form of expression may be free, as in the use of dialects, and text-books really are printed in over 40 different languages. But the content must be proletarian, thus hampering some of the customs relating to the old order which may be of value.

The Soviet way with the criminal is deserving of attention because of the originality of the methods employed. Institutes have been established for the study of crime and delinquency. An attempt is made to eliminate the motives leading to anti-social behavior and to reeducate the one who errs. Thus crime is believed to be an environmental problem and can eventually be "liquidated" as soon as every one is properly fed and clothed. The words "criminal" and "prison" are no longer used. Labor communes in factories or on farms have been substituted for prison bars, and the prisoner must work in order to eat. The Soviets think crime has decreased, but reliable statistics comparing the old and new orders are difficult to obtain. In fact, a comparison would mean little because of the vast differences as to what is considered criminal now and then. Recidivism has decreased, for only 20 per cent. of the criminals relapse into their old habits. The most frequent offenses are stealing, inefficiency and sabotage. Four factors dominate in the new theory: (1) abolition of long sentences; (2) industrial reeducation; (3) as normal a sex and family life as possible, and (4) removal of the prison stigma and bullying by attendants. Recognizing that one of the strongest motives to reform relates to the family the prisoner is allowed to go home at regular intervals, and a single person may marry. Due to the control over the individual by the rigid political system, these schemes appear to work. Delinquency is still a problem, especially among the homeless children with "declassed" or exiled parents. The state has been successful in caring for them in certain cases.

In many respects the most interesting and possibly the most significant psychological research relates to the treatment of mental and emotional disorders. The emphasis is on prevention rather than cure and the treatment—social rather than individual. In the world at large there is some evidence of the increase of

the common neuroses with civilization. Personality frustration in modern life is related to such factors as economic insecurity and unemployment, false motives, fears and anxieties; sense of sin and superstition associated with religion and excessive guilt feelings with sex as well as "mother fixations." At a recent congress of psychiatrists in Kharkov there was general agreement that the common neuroses had declined with the elimination of the sources of conflict mentioned above. Dementia praecox, still the most frequent organic disorder, has decreased by treatment of early symptoms in the school and factory. Manic cases are placed on "shock brigades" in the factories to use up their excess energy and thereby prevent excessive depressions. The secret political police rounded up the prostitutes, who were subsequently taught a socially useful task and made to believe they were wanted, in fact, badly needed in the building of socialism. Prostitution has practically disappeared, and consequently syphilis and paresis have decreased. Wide-spread propaganda in the factories and schools has controlled the excessive use of alcohol and hence delirium tremens is less frequent. Hysteria among the women is not encountered so often now that they play a more active rôle in society. Suicide is rare among the young people, but that was true in the old days. New problems have arisen with the intense and feverish activity of the new order, such as excessive fatigue and exhaustion. No doubt certain fears and guilt feelings remain relative to the secret police and the Russian indifference to work. One would like to have controlled experiments and reliable statistics to verify these impressions—but the indirect evidence at times is quite convincing. The emphasis on preventive medicine and social prophylaxis is an important contribution.

The research in the psychological laboratories of the larger universities is fairly extensive, but on the whole the most significant work relates to the institutes and vast social experiments in the new society. The research may be quite spotty and naive and often it is poorly controlled and statistically unreliable. At times the experiments are mere repetition of studies initiated elsewhere, and occasionally political opinion and bias play a part. But this phenomenon is not peculiar to Soviet Russia in a nationalistic world where politics distorts scientific thought the same as superstition and fear did in former days. Many of the approaches are original and the findings significant. As the political and economic systems settle down, we may look for scientific contributions from a people who have proved their creativity often in the past.

THE FUR-BEARERS OF NEW YORK STATE

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As a boy, the writer was regaled with stories of the fur trade of Canada and the far north. His source of information, the "Book of Knowedge" and various geographies, lent the impression that a rigorous climate and arctic storms were a necessary factor in the priming of full, heavily furred pelts. College geography texts of to-day do nothing to allay these beliefs in the laity, and the colorful romance of the oldest industry is built on tales of suffering and hardships, that Dame Fashion may cater to her ever-increasing needs.

Recently, the residents of Louisiana were astounded when Arthur[1] asserted the catch of furs in this subtropical state per annum exceeded that of all the Canadian Provinces and territories and Alaska combined. Because of the enormous numbers of muskrats taken (3 to 6 million annually) it is quite conceivable.

But what of the status of New York as a fur producer? How does the state with the largest population compare with others throughout the breadth of the Union? How does the Empire State contrast with its neighbors to the north, the Canadian Provinces and Alaska?

Listing the value of the raw fur catch of the 1924–25 season for fourteen states and Alaska, Arthur places New York seventh with an estimated annual catch of $1,500,000. Louisiana, Michigan, Pennsylvania, Minnesota, Tennessee and Alaska had a greater value, according to this report.

The intent of this paper is to demonstrate that New York, in spite of its populous nature, ranks second only to Louisiana in the annual harvest of its raw fur crop.

It is extremely difficult to amass accurate figures on the fur catch. Conservation officials make little attempt to secure trustworthy data, and are given little or no help from the trapper. Twenty-six states now seek information on the annual numbers of the fur-bearers taken each year. A very few states license their fur buyers.

In 1919, New York made an initial attempt to secure data on the numbers of fish, game and fur-bearers taken. Figures were secured by the county clerks when the hunter applied for a new license. While such figures give some indication of a fluctuation in numbers taken as might occur from year to year, they are notoriously inaccurate. In 1928 only 37 per cent. of the licensees reported taking game, while the following year, from a total of 627,541 licenses issued, returns were made on a third. We thus have reports on the numbers of animals taken by only a third of the licensed hunters. It would thus seem justifiable to multiply the reported annual take of any one species by three.

There is another factor, however, that accounts for a huge swelling in the reported numbers of the fur-bearers taken. In New York a landowner is permitted to trap his own property without a license, and boys under sixteen are likewise not handicapped with the necessity of buying a license. The reader not acquainted with trapping conditions in the United States will scoff at the idea of any appreciable amount of fur being taken, in the aggregate, by boy trappers. Yet a very large percentage of the furs in this country, the total value of which

[1] *Louisiana Dept. Conservation Bulletin* 18. 1928.

HOME OF HUDSON SEAL

A MUSKRAT MARSH OF CENTRAL NEW YORK. FIVE MUSKRAT HOUSES SHOW IN THE PICTURE, WHILE THE TRACKS OF A WANDERING MINK BORDER THE SNOW NEXT TO THE WATER.

has been computed to be worth $60,000,000 annually to the trappers, is taken by boys in the rural schools. Even in the New York City schools there are boys at the present time who make a good profit from furs taken on the trapline.

During the past eight years the writer has been engaged in making a study of the fur-bearers of New York and has amassed considerable data during the period. Not the least interesting is information on the number and value of the furs taken by minors. Eleven fur buyers, who bought, in the aggregate, 45,000 muskrats and 15,000 skunks, reported that 35 per cent. of these were trapped by boys under sixteen. One buyer states that 75 per cent. of his 2,500 skunk pelts were bought from young schoolboys.

The reader may object that the rarer, higher priced pelts are seldom trapped by boys. The important fur-bearers of New York are the muskrat, skunk, raccoon, mink, red fox and the weasel. The first two are, however, the important fur animals of the state, as they are throughout the nation. The muskrat is the pillar of the fur trade, having long since replaced the beaver. The muskrat and skunk, in New York, total in actual numbers taken ten times as many as all the other furbearers combined. A survey by the writer in 1931 of ten large fur buyers throughout New York state showed that skunks and muskrats totaled 142,000, while all the other species aggregated but 14,100. Furthermore, the value of skunk and muskrat comprise two thirds of all the money paid to the trapper in New York.

A few specific instances will dispel any suspicions the reader may enter-

tain regarding the numbers of furs taken by these precocious trappers. A fifteen-year-old boy trapped 100 muskrats, 21 skunks and 1 mink during a single season; another twelve-year-old took 14 skunks and 13 muskrats, while an eleven-year-old schoolboy trapped 8 'rats in a few weeks.

How does the world's largest city affect trapping conditions? As a fifteen-year-old boy, the writer trapped 30 muskrats at Flushing, eleven miles from Times Square, New York City. During the 1916–17 season two schoolboys took 300 muskrats and a mink at the same place. It seems incredible that two boys should harvest a crop of "Hudson seal" worth in excess of two hundred dollars, within sight of the New York City skyline, but such was the case. Other fur-bearers still hold their own within a few miles of the world's greatest metropolis. The weasel and opossum are not uncommon, while a few foxes and skunks yet remain.

From the foregoing facts, we must conclude that a third of the skunks and muskrats are trapped by unlicensed boys in New York. This, indeed, is a conservative estimate.

The Conservation Commission lists a third of a million muskrats taken in 1928. Inasmuch as only 37 per cent. of the hunters reported taking game, we shall feel justified in doubling the number of muskrats. Add to this the number taken by unlicensed boys and we have nearly a million 'rats secured by trappers for this year.

The Board of Game Commissioners of Pennsylvania estimated that over a million muskrats were taken during the two seasons of 1927–28 and 1928–29. Because of a mountainous topography, much of Pennsylvania is unsuited to muskrats, while New York, on the other hand, has far more marshes, creeks, extensive lakes and vast swamps that swell the total population of the amphibious mammals. Is it small wonder that we should expect to find New York leading her nearest eastern rival by twice the number of muskrats taken?

The skunk is second in value as a fur-bearer, not alone in New York but throughout the Union. The 72,623 skunks listed by the Conservation Department for 1928 falls far short of Pennsylvania's 1928–29 record of 254,608. Surely the mephitine population of New York is not less than that of Pennsylvania. The reason for the apparent disparity in the annual catch of the two states lies in the methodical manner Pennsylvania employs to secure accurate figures relative to her annual take of fur. If an attempt is made to determine a reasonably accurate figure on the number of trapped skunks, as was done for the muskrat, we find over 200,000 are collected in this one year. As a matter of fact, the writer knows a fur buyer who collected 22,500 skunks in one season in western New York.

In determining the catch of fur-bear-

TABLE 1

FUR-BEARING ANIMALS TAKEN IN NEW YORK STATE DURING 1928

	Listed in Annual Report of N. Y. State Conserv. Dept. 1930	Estimated total number taken	Estimated value
Muskrat	347,113	991,170	$1,486,755
Skunk	72,623	207,500	415,000
Weasel	....	75,000	37,500
Raccoon	27,886	55,772	334,632
Red Fox	10,616	21,232	318,480
Mink	7,133	14,266	171,198
Gray Fox	2,269	4,538	8,976
Opossum	1,328	2,656	1,859
Otter	1,135	2,270	56,750
Marten	183	366	7,320
Fisher	66	122	7,320
Bear	98	98	980
Bobcat	109	218	436
Totals	470,559	1,375,208	$2,847,206

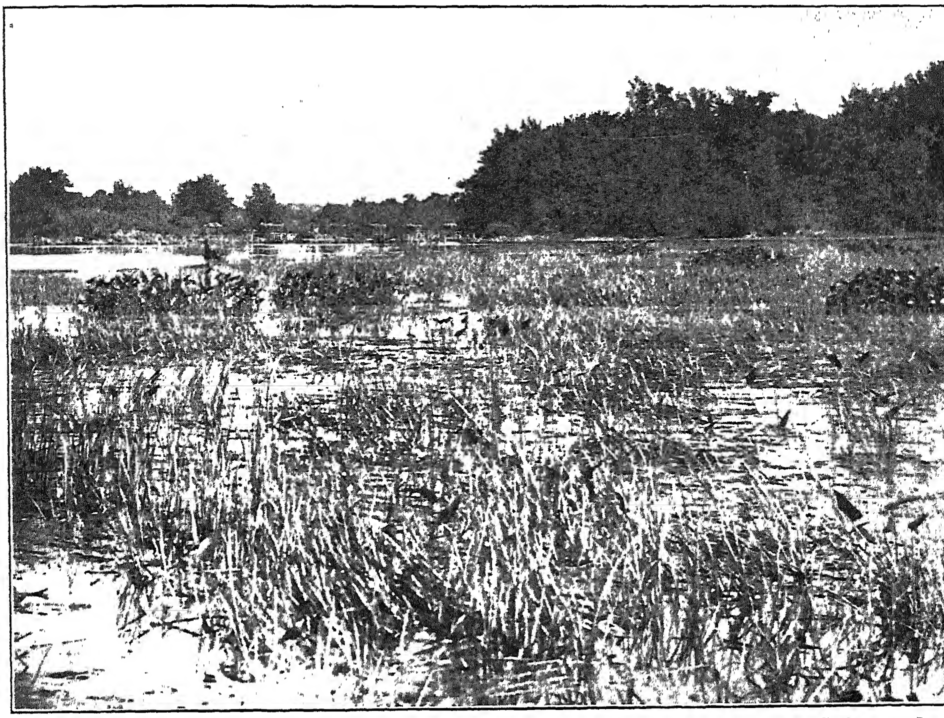


Photo by Dr. W. C. Muenscher

A WEEDY AREA IN AN ADIRONDACK RIVER

ARROW-HEAD AND PATCHES OF PICKEREL-WEED FURNISH FOOD FOR MUSKRATS AS WELL AS NESTING BLACK DUCKS.

ers other than muskrats and skunks in New York during 1928, we shall feel justified in doubling the numbers (excepting bear) listed by the state, as these latter figures represent but slightly more than a third of the licensed hunters' reports. Weasels are not even listed by the New York Conservation Department, but the probable catch each year in the state runs close to 75,000, according to earlier estimates of the writer.

Table 1, with estimates of the various species taken, is justified on the data already presented. It incorporates the numbers taken by unlicensed trappers and the huge number of licensed trappers who yearly neglect to file a return on their catch.

We thus have an estimated value on the New York State raw fur crop for 1928 of $2,847,206. Going a step further, we find a possible $6,501,363 fur crop for 1927, based partly on figures furnished by the Conservation Department (Annual Report, 1929, p. 238) and in part on the fur taken by unlicensed boy trappers and the many who make no report. We may regard the average prices for the pelts listed by the department as excessive (muskrats $2, skunk $2.50, mink, $17, etc.). Nevertheless, the catch may well have resulted in a five-million-dollar harvest to the trappers in this banner year of the fur trade.

If we compare these figures with Louisiana, we find that during the 1927–28 season, this southern state harvested a fur crop that brought the trappers $5,125,363. Thus New York compares remarkably well, at least in this year,

with Louisiana, which is generally accepted as the leader in fur production in the United States. Pennsylvania trappers, during the same season, took fur with an estimated value of $2,099,714.60. We need not concern ourselves with any other state, for, excepting Michigan, for which I have no figures, there is little or no comparison.

Turning to the Canadian Provinces, we find the Dominion Bureau of Statistics has gone to some trouble to secure accurate information on the value of the raw fur catch. The figures are based not alone on the reports of licensed fur traders, but combine annual statements, based on royalties, export tax, etc., to determine the approximate annual catch. The value[2] of wild caught fur-bearers from Canada, during the 1927–28 season, totaled $17,052,890. Thus New York produced in value of furs taken during the same period, a fourth as much as the entire Dominion during this period. Or in 1928–29, when the estimated value of wild caught fur-bearers in Canada amounted to $16,402,288, New York was harvesting a fur crop equal to a sixth of this. The vast province of Quebec, more than fourteen times the area of New York, produced considerably less, in numbers of animals taken and value received, than did the Empire State during the 1927–28 and the 1928–29 season. This does not mean, of course, that New York has more fur animals than Quebec. With probably ten times the number of trappers that the Canadian province produces, there is to be expected a considerably larger take of animals.

We have spoken of the quantity of fur taken in New York. Let us discuss briefly the quality. The finest muskrat pelts suitable for Hudson seal are taken in New York, especially from the central and western part of the state. The high quality of these pelts is reflected in the top prices paid for them. George I. Fox, New York fur merchant and head of one of the largest raw fur receiving houses in the world, writes to me that the average price for 1934 New York muskrats is $1.40, for Louisiana, $.65, while pelts from the central and western states bring $.80. He further states that New York muskrats are far superior to Canadian 'rats in size, color and quality.

The skunk, second in value only to the muskrat, is graded according to the amount of white in the fur. If the pelt has little white, it brings a good price. New York skunk will run 60 per cent. to No. 1's and 2's, those having little white, while these grades from Minnesota, Iowa and the Middle West will average less than 20 per cent.

Other furs from the Empire State are likewise graded as high-class pelts, bringing the value of the individual skins to the trapper considerably more than those taken in more southern latitudes.

Sufficient data have been presented to show that New York is a fur producer of the first rank. It is certainly the third, if not the second most important state in the Union as regards the value of fur-bearing animals. How may she best maintain this position? Present laws, while considerably improved over those of a decade ago, are not adequate to protect and perpetuate certain of the more valuable fur animals of the state. Some are in actual danger of extermination. The fox, a splendid game animal and fur producer, is given no protection. No closed season safeguards the fisher, highest-priced of New York fur-bearers, while the otter, with its prized, durable fur, is not given the benefit of any protection.

Personal correspondence and interviews with many buyers, most of whom

[2] Canada Yearbook, 1931.

have the interest of the fur animal at heart, tell the story of ever-decreasing yearly catches. It might be argued, particularly during the past few years, that this decrease is due to low prices paid for the pelts, which makes trapping unprofitable. The writer entertains serious doubts if the recent depression has safeguarded these animals. More are trapping to-day, if my observations are general, than did when prices soared skyward a few years back.

It is apparent to those who have investigated the situation that, with proper management, the suitable muskrat habitats can be made to produce three times the number of animals they now do. The extensive draining of swamps, too often unsuited to agricultural crops because of alkalinity or excessive acidity, has caused wide-spread decrease in the number of the animals during the past few years. The muskrat should be considered part of the agricultural crop on farms when conditions are favorable for the animal's natural increase. The value of the pelts that can be taken from an acre by sane trapping compare favorably with many farm products. A Buffalo man values his muskrat marsh at $35 per acre, and has cleared $5,100 in a single year from the sale of 'rat skins from this marsh.

Many of our fur-bearers have a value other than fur producers. The insectivorous habits of the skunk, the mouse-destroying proclivities of the fox and weasel and the sport of hunting furnished by the raccoon are in themselves sufficient reason for stringent laws that will protect these animals while the pelt is unprime.

Every state conservation department is now engaged in active propagation of fish and game birds to be turned free, either to replenish depleted areas with breeding stock or to furnish sport directly to the gunner or fisherman. Certainly we should provide for our fur animals, which furnish a sizable financial return along with the sport they produce. Little, if any, monies are turned back into the improvement of the fur resources of the states, yet the trapper pays an amount commensurate with that of the bird hunter or angler.

Certain reforms are immediately needed in the conservation of our fur-bearers. New York should grant a closed season to the fox and fisher during the period of their unprimeness the same as is now afforded the skunk, muskrat and raccoon. A qualified field agent should investigate needed changes in the various parts of the state, where certain species are in danger of extirpation. There are large areas in the state that are suitable only for fur production. The craze for extra agricultural land is over. Let a percentage of our extensive wild acreage return to its original state, which would mean more fur and game. Surely the state should give more thought to her fur-bearers, which, in normal years, pay interest, at 5 per cent., on a capitalization of $40,-000,000. Such an asset is certainly worthy of careful conservation and wise administration.

PRESIDENT KARL T. COMPTON

THE PROGRESS OF SCIENCE

DR. KARL TAYLOR COMPTON, PRESIDENT OF THE AMERICAN ASSOCIATION

Dr. Karl Taylor Compton, the new president of the American Association for the Advancement of Science, is one of America's most distinguished physicists. Born in 1887 in Wooster, Ohio, he is a son of Elias Compton, professor of philosophy and president of the College of Wooster. He spent his boyhood in the little Ohio town, attending the public schools there and doing his undergraduate work at the College of Wooster, from which he received a bachelor's degree in 1908.

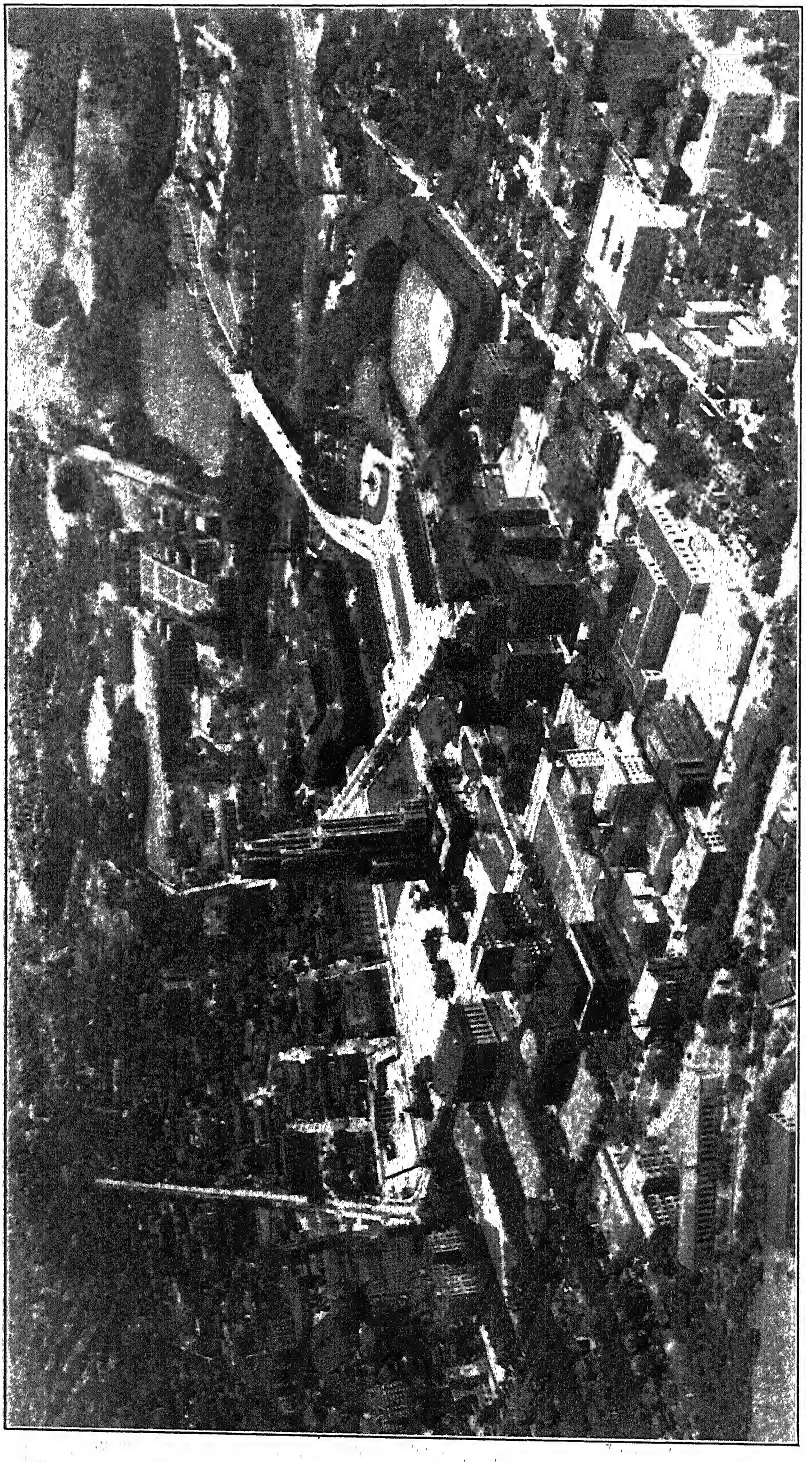
His first year of graduate work was also done at the College of Wooster, after which he went to Princeton University as a graduate student. His association with Princeton thus began at a time when the university was just beginning to be a center of scientific research in America. During the presidency of Woodrow Wilson, the university received large endowments for the development of the Graduate School and the Palmer Physical Laboratory was constructed. At that time Professor O. W. Richardson, the pioneer investigator of thermionics, was professor of physics at Princeton and doing much to stimulate electronic researches in Princeton's new physical laboratory. K. T. Compton, along with C. J. Davisson, who has just retired as vice-president for Section B of the American Association, became one of Richardson's ablest students. Thus it was that Compton early came under the influence of a great leader in research in modern electronic physics and received the training on which much of his later work is based.

After receiving his doctor's degree at Princeton in 1912, he spent two years on the faculty of Reed College in Portland, Oregon, before returning to Princeton as assistant professor in 1915. From then on he engaged in a program of researches which have contributed greatly to our understanding of the great variety of complex processes which occur in electrical discharges through gases. That work has a dual importance both for its bearing on fundamental problems of atomic structure and also because of the commercial importance of gas discharges as sources of light.

It will be recalled that this was the period in which the great "boom" in atomic physics started by the Bohr theory was just getting under way. Prior to that theory, empirical spectroscopists had found it possible to analyze spectra by introducing mysterious numbers called "terms" associated with the atoms. These numbers were such that the number of waves in unit length in the lines of the spectrum emitted by an atom could be expressed as differences between them. Bohr's theory provided the interpretation of the terms as being proportional to the actual energy content of the atom in various possible energy states and postulated that the emission of radiation took place when an electron in the atom jumped from one energy state to another. One way of testing this hypothesis was by a study of the process whereby atoms are excited on being struck by electrons having a known kinetic energy, the field of research known as the study of critical potentials. In this field, Compton's experiments were of the first importance and did much toward establishing firmly the physical reality of this essential hypothesis underlying the Bohr theory.

These researches were interrupted for a time during the war when Compton served as scientific attaché to the American Embassy in Paris.

After the war he was elevated to a full professorship at Princeton and there,



AN AIRPLANE VIEW OF THE ACADEMIC CENTER IN PITTSBURGH

SHOWING THE CATHEDRAL OF LEARNING A LITTLE TO THE LEFT OF CENTER WITH OTHER BUILDINGS OF THE UNIVERSITY OF PITTSBURGH IN THE FOREGROUND. THE BUILDINGS OF THE CARNEGIE INSTITUTE OF TECHNOLOGY ARE IN THE BACKGROUND. THE CARNEGIE INSTITUTE BUILDING, CONTAINING THE MUSIC HALL AND THE MUSEUM, LIES BETWEEN THEM AND THE CATHEDRAL.

under his stimulating guidance, there was gradually assembled a large group of experimental research workers engaged in the study of a great variety of problems in fundamental atomic physics and in the processes involved in gas discharges. Some years later he was appointed to the newly founded Cyrus Fogg Brackett professorship of physics, which permitted him to devote his full energies to the development of the graduate work in physics. During this period his original work and his enthusiastic efforts for the development of scientific research in America resulted in his being generally recognized as a leader of American physics. From 1927–29 he served as president of the American Physical Society. During this period he was also associated in an important capacity with the work of the National Research Council and the National Academy of Sciences.

While contributing much to pure science by his researches, he always had a keen interest in the fundamental scientific problems of technology. Therefore it was only natural that the Massachusetts Institute of Technology, faced with the need of filling the presidency, should turn to Dr. Compton. In the spring of 1930 he was persuaded to accept the presidency and thus the Princeton period was brought to a close. This selection may well mark a turning point in the development of technical education in America. American engineers have always been intensely practical fellows. The technical schools, accordingly, have given students plenty of training in shop and testing room, but have been regrettably laggard in giving sound training in the most modern and advanced phases of physics. Such a plan of study may have been appropriate for an earlier period in technology, but nowadays there are so many great industries which are directly founded on the results of modern physics that it is evident that a first-rate technical education must include a thorough grounding in basic pure science. Realization of this fact undoubtedly was the guiding idea in the minds of the men responsible for urging Compton to go to Cambridge.

In the four years which he has served as head of "M. I. T.," great changes in the institute have been effected in the direction of strengthening the work in fundamental science. A noteworthy feature of this growth has been its close integration with the technological studies at the institute. These developments will undoubtedly lead to a new and higher conception of technical education in America. That so much has been accomplished in these four years is, of course, all the more remarkable in view of the severe economic conditions of the time.

At the beginning of the present administration, Dr. Compton was selected by President Roosevelt as chairman of his Scientific Advisory Council, charged with working out a scientific program for the "New Deal." The council's first major accomplishment has been the development of a program for modernization and development of the nation's meteorological service, a plan which calls for adoption in practise of the new methods in meteorology which have been so successfully developed in Norway by Professor V. Bjerknes. The council is also hard at work on the details of a coordinated plan for the support of fundamental research in connection with the extensive public works program of the government.

In conclusion, let no one think of an antithesis between scientific research and administrative activity in connection with K. T. Compton. In spite of his great activity as administrator, Compton keeps in close personal touch with the work of the physics laboratory and finds time to supervise his own program of experimental work in spectroscopy in the M. I. T. research laboratories.

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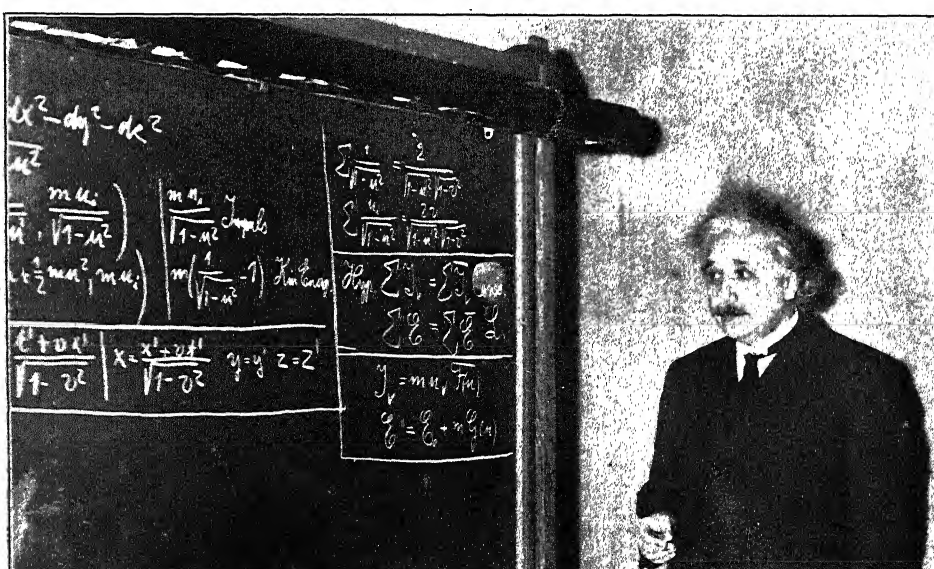
THE AMERICAN ASSOCIATION AT PITTSBURGH

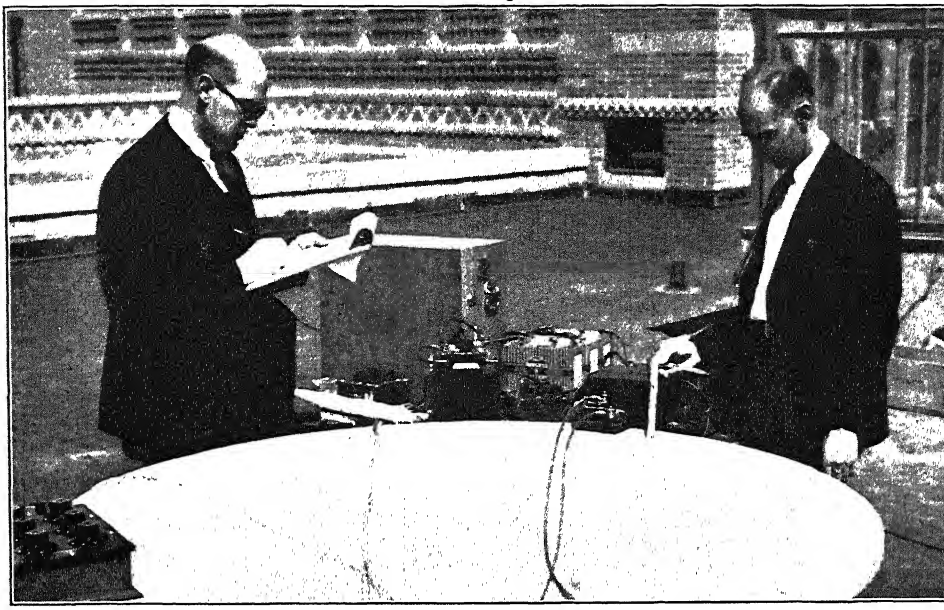
THE winter meeting of the American Association for the Advancement of Science was held in Pittsburgh from December 27 through January 1. Many of the sections and affiliated societies presented programs of great interest and importance. A few of those that may be mentioned were: the symposium on "Heavy Hydrogen and its Compounds," given before the sections of physics and chemistry; the symposium of the American Society of Naturalists on "Cytogenetic Evolutionary Processes and their Bearing on Evolution Theory"; Monday afternoon's discussion before the section of social and economic sciences on "Contemporary Economic and Social Problems under the New Deal" at which two assistant secretaries from the New Deal found themselves pitted against a Harvard professor in animated argument; and the same section's Tuesday evening program on "Economic Planning."

The general sessions of the association, held in the evening at the Carnegie Music Hall, presented Dr. William Alanson White, superintendent of St. Elizabeth's Hospital in Washington; the Sigma Xi Lecture by Professor E. A. Hooton of Harvard; the address of the retiring vice-president of the engineering section, Charles F. Kettering, of the General Motors Corporation; and the address of the retiring president of the association, Professor Henry N. Russell, of Princeton, who spoke on "The Atmospheres of the Planets." The eleventh annual Josiah Willard Gibbs Lecture, presented under the auspices of the American Mathematical Society, was delivered by Professor Albert Einstein, of the Institute for Advanced Study. Because of the strict limitation which was of necessity placed upon the number who could attend, this session produced much local comment. The lecture was the presentation of a highly technical subject, despite its title of "An Elementary Proof of the Theorem Concerning the Equivalence of Mass and En-



PROFESSOR ALBERT EINSTEIN IN PITTSBURGH

DELIVERING THE ELEVENTH JOSIAH WILLARD GIBBS LECTURE UNDER THE AUSPICES OF THE AMERICAN MATHEMATICAL SOCIETY.



PROFESSOR VERN O. KNUDSEN

WHO WAS AWARDED THE ASSOCIATION PRIZE AND L. P. DELSASSO (RIGHT) WITH THEIR APPARATUS FOR THE STUDY OF SOUND. BOTH ARE MEMBERS OF THE DEPARTMENT OF PHYSICS OF THE UNIVERSITY OF CALIFORNIA AT LOS ANGELES.

ergy," by the outstanding authority in that field.

The association's prize of $1,000 was awarded to Professor Vern Oliver Knudsen, of the University of California at Los Angeles, for his paper on "The Absorption of Sound in Gases" delivered at the joint session of the American Physical Society with the Acoustical Society of America. The paper is of importance because of its theoretical implications with regard to energy states of the molecule, as well as on account of its application in the field of practical acoustics.

The council of the association elected as president Dr. Karl T. Compton, president of the Massachusetts Institute of Technology. It elected Otis W. Caldwell, of Teachers College, Columbia University, general secretary, to replace Professor Burton E. Livingston, whose resignation was accepted with great regret. Dr. Earl B. McKinley, dean of the George Washington University Medical School, was elected to fill the unexpired term of President Compton on the executive committee.

The scientific and commercial exhibits of the association were well attended, not only by members but by the general public as well. Indeed, the public began its examination of the exhibits on the day before the sessions began and increased in number until, on Sunday afternoon, the exhibition halls came close to congealing and visitors could be admitted only when others left. Thousands, discouraged by the long wait for admittance, were unable to wait and many hundreds had to be turned away.

It is unfortunate that these meetings should partake so essentially of the character of a twenty-ring circus. Affording, as they do, the only opportunities for investigators in widely different fields to commingle, the crowded nature of the programs almost requires that one

attend only his own section meetings. Under these conditions, the reception, the biologists' smoker, the smoker for mathematicians, physicists, chemists and engineers and the section or society dinners assume added importance. Events of this nature to which your correspondent could go were very well attended and very much worthwhile.

The president, Dr. Edward L. Thorndike, the distinguished psychologist of Columbia University, presided over one of the most successful gatherings in the history of the association. Nearly 3,000 scientific men and women officially registered for the sessions; the active attendance was over 4,000. The director of exhibits reports that more than 20,000 people visited the research and commercial exhibition in the basement of the new Mellon Institute building.

H. D.

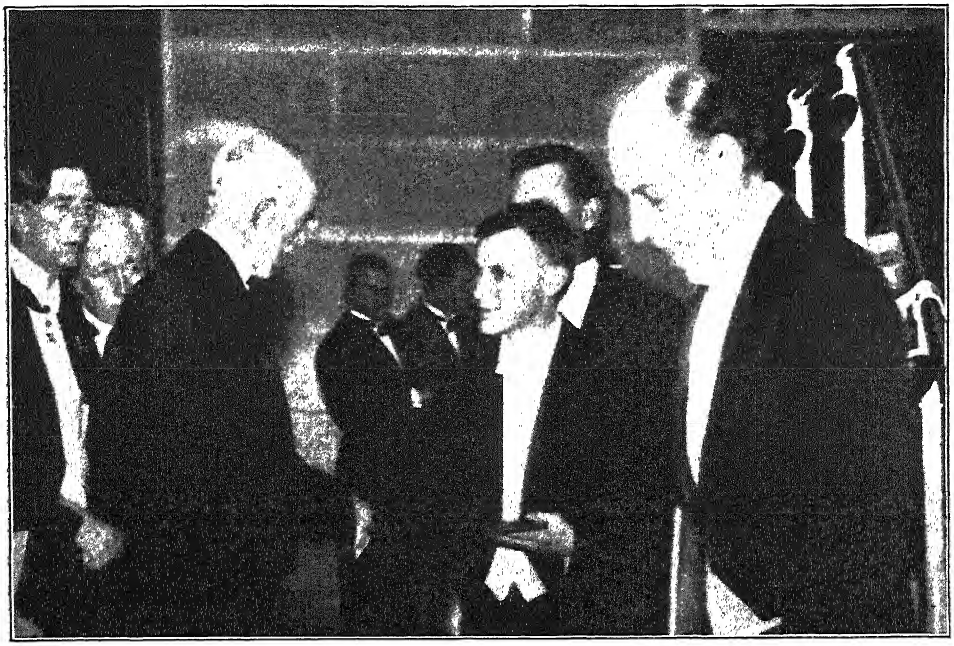
AWARD OF THE NOBEL PRIZE FOR THE TREATMENT OF ANEMIA

The award of the Nobel Prize in medicine and physiology jointly to Drs. George Richards Minot and William Parry Murphy, of Boston, and to Dr. George Hoyt Whipple, of Rochester, New York, for their discoveries in the treatment of anemia symbolizes the high regard in which their contributions are held by the medical world. It may be truly said that the great advances of the past decade in the understanding of disorders of blood formation have been made either by these men or as a direct result of their work. Begun in the laboratory as an experimental study of pigment metabolism, the unforeseen result has been the successful treatment of a hitherto fatal disease in man.

Dr. Whipple, formerly director of the George Williams Hooper Foundation for Medical Research of the University of California, became in 1921 dean and professor of pathology of the University of Rochester Medical School. Almost twenty years ago he began a series of carefully planned observations in animals upon the mechanism of the production of hemoglobin and its relations to biliary pigments. A technique once perfected, there issued from his laboratories a series of publications which have placed upon a secure quantitative basis the vague belief of former generations that the quality of the blood depended upon the quality of the diet. He and his associates proceeded with beautifully executed experiments to accumulate information, especially upon the amounts of hemoglobin which could be formed in a given period of time by a variety of food substances. The properties of fats, fish, vegetables, cereals, fruits, meat and liver were investigated in this respect. By 1922 cooked beef muscle, heart and liver were recognized as especially favorable for the regeneration of red blood cells and hemoglobin in dogs rendered anemic by repeated bleeding.

Characteristic of Dr. Whipple himself are the outstanding features of his work: the direct approach to the theoretical problem that interested him, the persistence of the attack and the conservatism of the conclusions drawn only after prolonged experimentation. Imagination there is, but disciplined by a profound respect for the verifiable fact. Thus, he suggested that pernicious anemia might be a disease in which there was a scarcity of material necessary for the construction of the stroma of the red blood cells. Nevertheless, he cautioned others against the hasty assumption that the results of his experiments in animals could be directly applied to the problems of anemia in man.

Dr. Minot was appointed in 1928 professor of medicine at Harvard and since then has also been director of the Thorndike Memorial Laboratory of the Boston



PRESENTATION OF THE NOBEL PRIZES

King Gustaf of Sweden presenting the Nobel Prize in medicine and physiology. Professor George H. Whipple, whose portrait was printed in The Scientific Monthly for December, is partly hidden by Dr. William P. Murphy, who is receiving the award. Dr. George R. Minot is in the foreground on the right.

City Hospital. Since graduation from the Harvard Medical School in 1912, he has pursued an interest in diseases of the blood. The acquaintance with the subject gained in teaching and research became a rare intimacy in the practise of medicine. As time passed, he accumulated by piecing together fragmentary impressions and observations, as is often necessary in clinical medicine, a belief that dietary deficiency was in some way related to the cause of pernicious anemia. After numerous unsuccessful attempts at treatment of the disease with various types of diet, he beheld, in a few private patients given small amounts of liver in the diet, the faint light preceding the full dawn of discovery. It is significant that other clinicians fed liver to patients at about the same time without noting anything unusual as a result. Based on his profound clinical knowledge of the disease, his conviction that dietary inadequacy was at its root, and undoubtedly influenced by the implications of the studies of Whipple, he persisted. He and Dr. Murphy observed that a diet containing considerable amounts of liver was regularly beneficial to patients with pernicious anemia. Together they announced in 1926 the results of their successful treatment of 45 patients, most of whom by that time would otherwise have been dead. This work and their subsequent development of extracts of liver, which have made the method of treatment eminently practical, have been stamped with attention to quantitative detail. In addition to its intrinsic merit, it is an example of the possibility and value of quantitative observation in the clinic, forming a fitting counterpart to the experiments of Whipple in the laboratory.

Dr. Minot's contribution is again characteristic of the man. An observer less able to carry in mind a variety of clinical details would have failed to recognize the essential problem in pernicious anemia. His enthusiasm for investigation caused him to persist with diet therapy in the face of what was to others obvious failure. To him the slightest improvement was never spontaneous but the result of causes obscure, but nevertheless not too difficult or too unimportant to search for. Dr. Murphy, who since 1928 has been instructor in medicine at the Harvard Medical School and associate in medicine at the Peter Bent Brigham Hospital, possessed the calm judgment and untiring energy indispensable to a complete demonstration of their discovery.

Not only has the value of the contributions of these men already been realized, but also great will be the effect of their discoveries upon the medicine of the future. Even now in the light of these events much has been learned concerning the causation of pernicious anemia and its relatives close and distant in the family of diseases. In the field of alimentary tract diseases and in disorders of the nervous system, new points of view have been developed. It is unnecessary to enumerate the many honors which have come to these men, since there is no greater achievement in science than to have laid a firm foundation upon which others may confidently build a structure of new knowledge.

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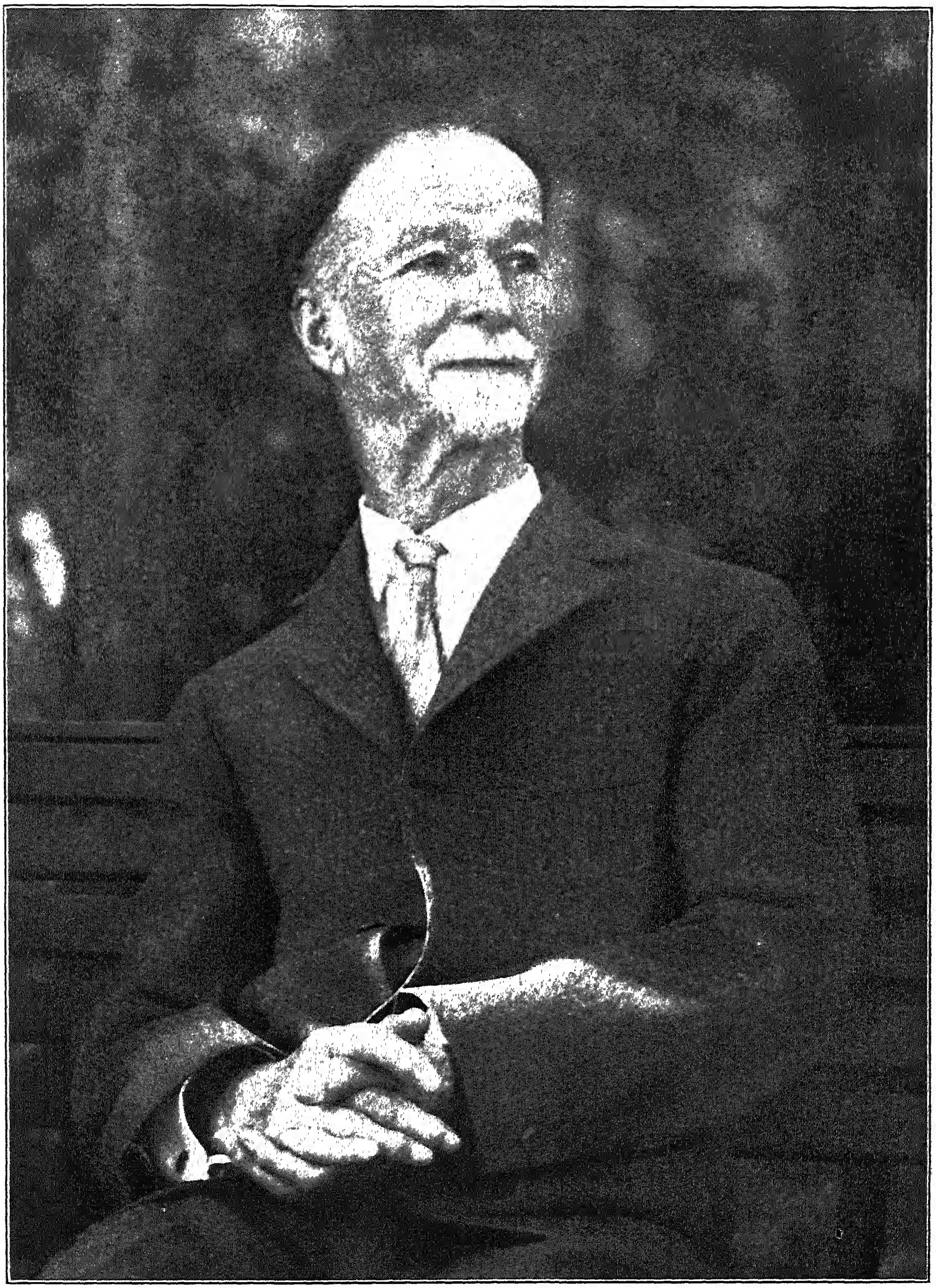
THEOBALD SMITH, 1859–1934

The death of Dr. Theobald Smith on December 10, in his seventy-sixth year, was an irreparable loss to medical science. He was distinguished for his work on the comparative etiology, pathology and immunology of infectious and parasitic diseases. At the time of his death he was president of the board of scientific directors and member emeritus of the Rockefeller Institute for Medical Research.

After his graduation from Cornell University Dr. Smith obtained his medical degree from the Albany Medical School. He had been chief of the Division of Pathology of the U. S. Bureau of Animal Industry for a number of years as well as professor of bacteriology at George Washington University when in 1895 he was called to Harvard to fill a chair in applied zoology; the following year he was appointed professor of comparative pathology. In 1914 he accepted a call from the Rockefeller Institute for Medical Research to fill the directorship of the Department of Animal Pathology at Princeton, New Jersey, a position in which he was active until 1929.

While he was in charge of investigating infectious animal diseases for the Bureau of Animal Industry, Dr. Smith demonstrated that ticks were the means of the transmission of Texas cattle fever. The results of this investigation were important, as it was the first proof that insect hosts are the essential intermediate agencies in the spread of some infectious diseases of great importance to man.

Probably his next best-known work is the differentiation of bovine from human tubercle bacilli. Hitherto the differing types of disease caused by these organisms had not been recognized. Koch, the original discoverer of the tubercle bacillus, at once realized the significance of Dr. Smith's work which has played a far-reaching part in the control of tuberculosis.



THEOBALD SMITH

A PHOTOGRAPH TAKEN ON HIS SEVENTY-FIFTH BIRTHDAY BY DR. CARL TENBROECK.

The investigation of blackhead, a fatal disease of turkeys, occupied much of Dr. Smith's time, and he was able to show that the condition was caused by the interaction of a nematode worm and a protozoan parasite. No such association of organisms as a cause of disease had been recognized previously and its significance for human and animal pathology can not yet be fully appraised.

Dr. Smith demonstrated that colostrum, the thin fluid that new-born animals suck from their mothers before the breast yields milk, has notable antibacterial and protective action. It was shown that when colostrum was withheld from new-born calves a large majority died from wide-spread infection with bacteria that are ordinarily harmless. Limitations of space make it possible to mention only three other discoveries made by Dr. Smith. As far back as 1894 he experimentally induced scurvy in guinea-pigs; he first demonstrated that killed cultures of bacteria may produce immunity; he discovered the immunizing action of balanced or neutral mixtures of diphtheria toxin-antitoxin in guinea-pigs and suggested their use for the prophylaxis and treatment of diphtheria.

Dr. Smith was the recipient of many honors from institutions in this country and abroad. Among those that conferred on him honorary degrees were Princeton University, Harvard University, the University of Chicago and the Universities of Edinburgh and Breslau; he was a member of the National Academy of Sciences and of scientific societies in many countries. In 1933 the Royal Society of London honored him with its Copley Medal.

In speaking of the personal qualities of Theobald Smith in the eulogy that he gave at the funeral service in Princeton, Dr. Charles R. Stockard said:

> Dr. Theobald Smith began his scientific life, and continued it, as a simple unassuming student of nature. He was in the highest sense a naturalist. He was devoted to simple understanding and constructive thinking. Complexities and uncertainties were realities to him, but his mind made no attempt to encompass complexities. The direction of his thought was toward finding some means of reduction to elementary simplicity.
>
> He was clear-minded, strict-minded and absolutely honest. He was tolerant where tolerance is a virtue, but was emphatically intolerant of any compromise with error. He avoided every semblance of deceit, he was unpretentious and was most careful not to deceive himself. While in a world of cloudy and confused thinking with bungling attempts at the solution of pressing problems it is a joy and inspiration to have known a mind of such direction and clearness as that of Theobald Smith.
>
> Dr. Smith's genius displayed to a high degree the rare quality of foresight. He visualized the line of attack on a broad problem as the master artist in his imagination sees the finished creation before it is begun. He carefully proceeded along the line of his interest step by step with a seeing eye and a penetrating appreciation of the meaning in what he saw. To him the greatest reward was the solution of the problem and toward this his efforts were ever turned.

C. W.

THE SCIENTIFIC MONTHLY

MARCH, 1935

DEVELOPMENT OF CHEMICAL SYMBOLS

By Professor INGO W. D. HACKH

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THE development of chemical concepts is reflected in the history of chemical symbolism. Man has always tried to make pictures because visual instruction is most direct, and if pictures failed, he created symbols. Just as our alphabet[1] developed from picturegram to ideogram and ultimately to the phonogram, so the chemical symbols of to-day have undergone a development which may be traced to the Egyptian hieroglyphs.

A picturegram, such as a hieroglyph, can not be constructed for a chemical substance, because the appearance of any material substance is not sufficiently distinct. We may draw the picture of a hammer or saw, but we can not picture water, salt, gold or wine. Hence it is not surprising that the old Egyptians used the ideogram and later the phonogram for representing substances and materials. The hieroglyph for palm wine (Fig. 1) is of this nature and is a combination of a palm leaf and a jug; for wine in general (Figs. 2, 3), the first a phonogram *sha-t,* the later the conventional sign, consisting of two wine jars, presumably filled. Honey is depicted by a bee and a closed small jar (Fig. 4). The conventional hieroglyph (Fig. 5) for gold contains as its essential feature a symbol (Figs. 6 and 7) which in its older form (Fig. 6) is a cloth bag from which water runs. It is supposed to be held by both ends by two slaves who wash the gold from the river (the slaves are not shown, for their presence would mean the act of washing gold). There were several kinds of gold known to the Egyptians, *nub-en-mu* or river gold (Fig. 8) and *nub-en-set* or mountain gold (Fig. 9) which are characterized by the zigzag line indicating water (Fig. 22) and the three mountain peaks. Silver, closely allied to gold, has for its symbol (Fig. 10) *white metal* by imposing the ideogram *light* upon that of gold. Naturally occurring alloys of gold and silver (Fig. 11) *white gold,* is distinct from the *gilding of silver* (Fig. 12) or the hammering of gold upon silver objects, and its hieroglyph clearly indicates the human agency necessary. The third important metal, copper, is shown by a crucible (Figs. 13, 14, 15 and 16) which later becomes conventionalized to Fig. 17. Hieroglyph 13 is the *metal from the North,* and 14 the *metal from the South,* where the central bowl-like symbol designates metal, generally copper, and the luxurious plant of the moist Nile muds stands for north, as compared with the arid desert plant indicating south. In hieroglyph 18, *weapons made from copper,* we have an example of combining copper and spear.

The fact that iron and lead came at a later date is shown by their hieroglyphs, which are phonograms instead of ideograms. Thus Fig. 19 spells

[1] "History of the Alphabet," SCIENTIFIC MONTHLY, 25: 97–118, August, 1927.

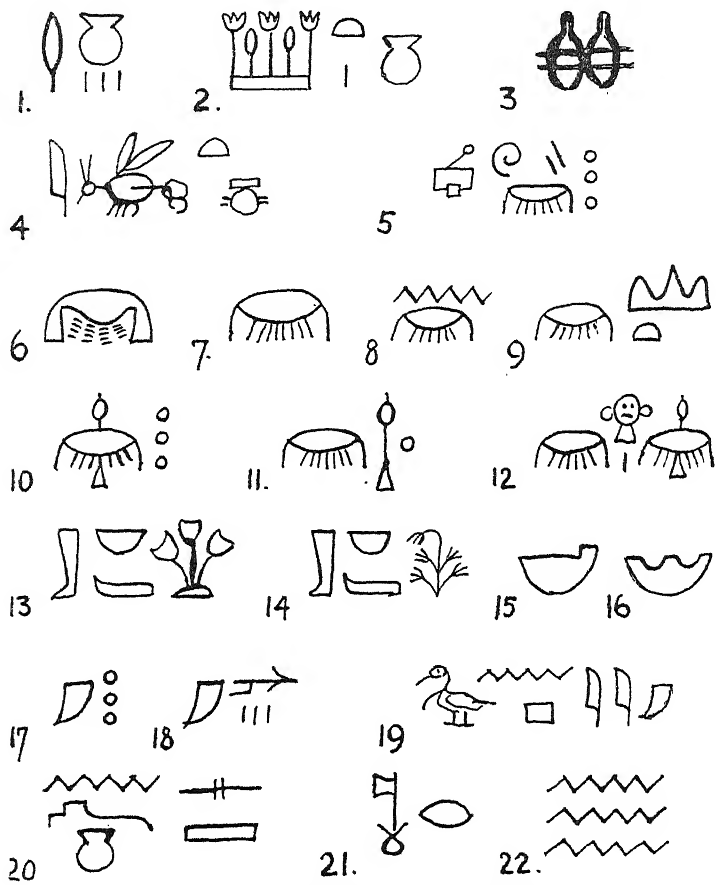

PLATE 1. EGYPTIAN HIEROGLYPHS
1–3, WINE. 4, HONEY. 5–9, GOLD. 10, SILVER. 11, 12, SILVER-GOLD. 13–17, COPPER. 18, WEAPONS OF COPPER. 19, IRON. 20, LEAD. 21, NITRE. 22, WATER.

banpi, iron, for in this hieroglyph the pictures have a phonetic value. Fig. 20 means a *block of lead, nus,* in both of which the symbol for water (Fig. 22) has the phonetic sound *n*. Hieroglyph 21 stands for *netra* or *nitre,* to purify or cleanse by means of incense.

By various channels the hieratic and demotic characters of the Egyptians were borrowed by traders, officials and soldiers and spread north and west to the Baltic and Greece, south and east to Ethiopia, India and Mongolia. With the invention of phonetic writing it is not surprising to find that the Greeks and Romans had no symbols for chemical substances, for the written language was sufficient to express the idea. Thus *hydrargyros,* a combination of *hydor,* water, and *argyros,* silver, sufficiently identifies *water-silver* or mercury. No symbols are needed, when words suffice.

But with the rise of alchemy and the philosophical speculations implied thereby, symbolism flared up anew. The alchemists were inductive and speculative, the modern scientist is inductive and experimental. The alchemist first formed a concept of the universe surrounding him and then argued from his theory what the behavior of nature should be. Philo-

sophical speculation was in higher esteem than practical experimentation. Few alchemists stooped so low as to actually experiment, and those who did made history; as, Geber, Basil Valentine, Paracelsus, etc. In their writings it was customary to conceal rather than reveal facts, and for this purpose each respectable writer developed his own symbolism. This naturally made the writings more mysterious and difficult to understand and the reader had thus plenty of lee-way in speculating as to the meaning. Failure of transmutation or the non-appearance of the elixir of life and the philosopher's stone was merely due to misinterpretation of the symbols. Some of these symbols, shown in Plate 2, were used during the fifteenth, sixteenth and seventeenth centuries. The symbols for arsenic (Fig. 23) show various forms of the *dragon's head* or azimutal node sign as well as a cross and triple cross on account of its toxicity. Gold (Fig. 24) is always associated with the Sun or aurora; iron

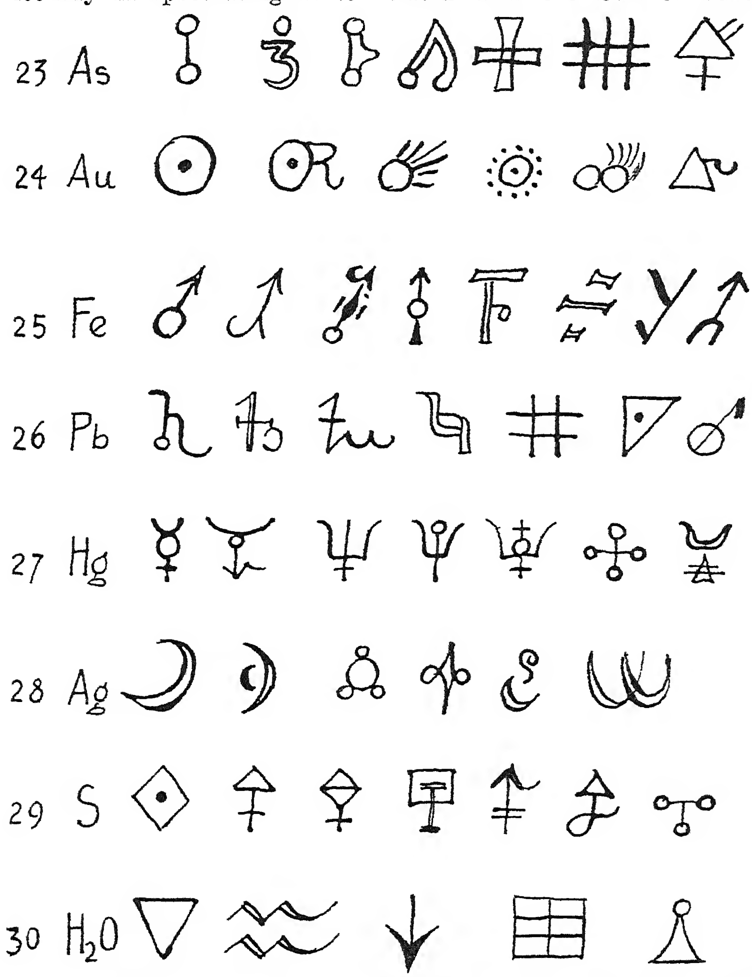

PLATE 2. ALCHEMICAL SYMBOLS OF THE 15TH, 16TH AND 17TH CENTURIES, SHOWING THE ASSOCIATION OF ASTROLOGY AND ALCHEMY

23, ARSENIC. 24, GOLD. 25, IRON. 26, LEAD. 27, MERCURY. 28, SILVER. 29, SULFUR. 30, WATER.

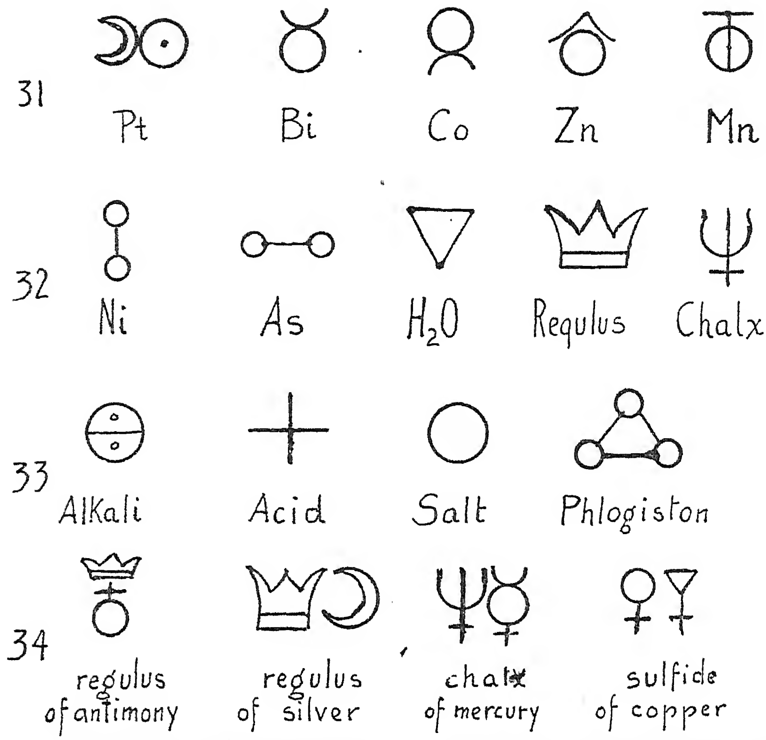

PLATE 3. BERGMAN SYMBOLS FROM HIS *OPUSCULA PHYSICA ET CHIMICA* (1783)

31, NEW DISCOVERED METALS. 32, 33, CONVENTIONALIZED SYMBOLS FOR CERTAIN CONCEPTS AND MATERIALS. 34, COMBINATION OF SYMBOLS.

(Fig. 25) with Mars, spears and weapons; lead (Fig. 26) with Saturn or on account of its poisonous nature with a double cross. Mercury (Fig. 27) is represented by the symbol of Mercurius in its various forms, as well as by a single cross. Silver (Fig. 28), next to gold (Sun), receives the next brightest celestial body, Moon, for its symbol; this association still survives in *lunar caustic.* Sulfur (Fig. 29) has a synthetic symbol resembling copper (venus) while water (Fig. 30) is either a triangle or a wave-line, curiously enough resembling the Egyptian hieroglyphic and the predecessor of the letter N or n.

The alchemistic symbols, however, became more and more conventionalized, hence toward the end of the seventeenth century certain symbols were universally used. In the *Pharmacopoeia Batanea,* compiled in 1694 by William Salmon, we find an emancipation from mystical allegories, for although the astronomical signs are preserved for the metals, they have no astrological meaning. Some of his symbols are:

- ☉ sol (Sun) or gold
- ☽ luna (Moon) or silver
- ♀ Venus or copper
- ♂ Mars or iron
- ♄ Saturn or lead
- ♁ Stibium or antimony
- ☿ Mercury or quicksilver
- ♃ Jupiter or tin
- ♌ arsenic
- O alum
- * sal ammoniac

In this list the symbol of antimony is listed also as *stibium* but not as *earth.*

The tenacious hold of astrology on alchemy is shown as late as 1781, when the planet Uranus was discovered and its symbol was given to platinum.

The next important step in symbolism may be traced in the writings of Torbern Olof Bergman (born March 20, 1735, in Katharinenburg (Westgothland) Sweden, died July 8, 1784). Bergman was professor of chemistry, physics, pharmacy and mineralogy at the University of Upsala and a prolific writer. Best known are his *Historia Chemiae medium seu obscurum aevum* (Upsala, 1782) and *De primordiis Chemiae* (Upsala, 1779). He describes the qualitative reactions of gold, platinum, silver, mercury, lead, copper, tin, bismuth, nickel, arsenic, antimony and manganese and gives accurate directions

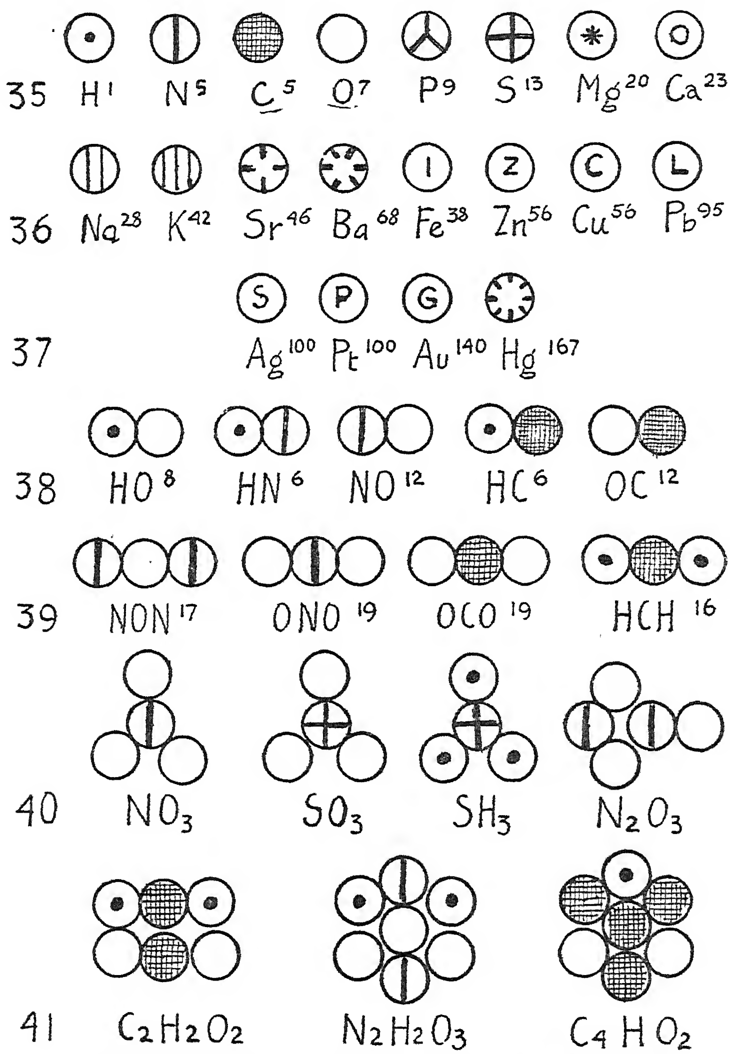

PLATE 4. DALTON SYMBOLS AND ATOMIC WEIGHTS

35–37, ELEMENTS. 38, BINARY COMPOUNDS. 39, TERTIARY COMPOUNDS. 40, QUATERNARY AND QUINQUENARY COMPOUNDS. 41, SEXTENARY AND SEPTENARY COMPOUNDS (ACETIC ACID, AMMONIUM NITRATE AND SUGAR).

for the analysis of ores containing these elements by means of hydrogen sulfide. In his writings he uses the customary astrological symbols for the metals; however, as he dealt with more metals than there were astronomic signs, he had to invent new ones. Some of these symbols are shown in Figs. 31, 32 and 33. For platinum, a noble metal, he chose a combination of the signs for gold and silver. He conventionalized the symbols for regulus (metallic globule), chalk (oxide or ash) and phlogiston, but more important he began combination of symbols (Fig. 34), which may be considered as containing the germ of the modern formula. Thus *regulus of antimony* or *regulus of silver* indicated the uncombined metal, but *chalk of mercury* was the oxide of mercury.

Into this atmosphere of symbolism was born John Dalton on September 5, 1766, at Eaglesfield, Cumberland, as the son of a poor weaver. He started his career in 1781 as apprentice teacher, then in 1785 with his brother headmaster of a school in Kendal and beginning in 1793 teacher of physics and mathematics in the New College of Manchester, where he died on July 27, 1844. In the year 1808 his classic "New System of Chemical Philosophy" was published, and thus the cornerstone for the law of multiple proportions and the atomic theory was laid. It is not surprising that Dalton used symbols for the atoms, all of them being circles having a different geometric design, and when the easily recognizable patterns were exhausted, the initial letter of the elements were used (Figs. 36 and 37). He thus paved the way for the Berzelius symbols, just as the Bergman symbols paved the way for him (Fig. 34).

The term molecule was unknown and thus Dalton classifies the compounds into binary atoms (Fig. 38), ternary (Fig. 39), quaternary, quinquenary (Fig. 40), sextenary and septenary atoms (Fig. 41). The starting point of his theory was the *light* and *heavy* hydrocarbon gas (methane and ethane), and as he used equivalent weights instead of atomic weights, his resulting formulas are not identical with the present ones. Thus water is described as "an atom of water or steam composed of 1 of oxygen and 1 of hydrogen, retained in physical contact by a strong affinity and supposed to be surrounded by a common atmosphere of heat" (Fig. 38). The other symbols are

Fig. 38: HO = water (H_2O)
NO = nitrous gas (NO_2)
OC = carbonic oxide (CO_2)
HN = ammonia (NH_3)
HC = olefiant gas (C_2H_6)
Fig. 39: NON = nitrous oxide (N_2O)
OCO = carbonic acid (H_2CO_3)
ONO = nitric acid (HNO_3)
HCH = marsh gas (CH_4)
Fig. 40: NO_3 = oxynitric acid (N_2O_4)
H_3S = sulfuretted hydrogen (H_2S)
SO_3 = sulfuric acid (H_2SO_4)
N_2O_3 = nitrous acid (NNO_2)
Fig. 41: $H_2C_2O_2$ = acetic acid ($C_2H_4O_2$)
C_4HO_2 = sugar ($C_6H_{12}O_6$)
$H_2N_2O_3$ = nitrate of ammonia (NH_4NO_3)

While during the lifetime of Bergman 14 new elements, including oxygen, nitrogen and hydrogen, were discovered, the life of Dalton witnessed the discovery of not less than 39 new elements. In the same period falls the beginning of modern chemistry, electrolysis, qualitative and quantitative analysis, and the names of Davy, Klaproth, Tennant, Vauquelin, Courtois, Wollaston and many others are well known, but Berzelius stands foremost.

Jöns Jakob Berzelius was born on August 29, 1779, in Wäfversunda (Eastgothland), Sweden, and died on August 7, 1848, in Stockholm. He first studied medicine, later chemistry in Upsala and Erlangen and in 1807 became professor of chemistry and pharmacy in Stockholm. A year after Berzelius began his duties Davy isolated calcium, magnesium and boron by elec-

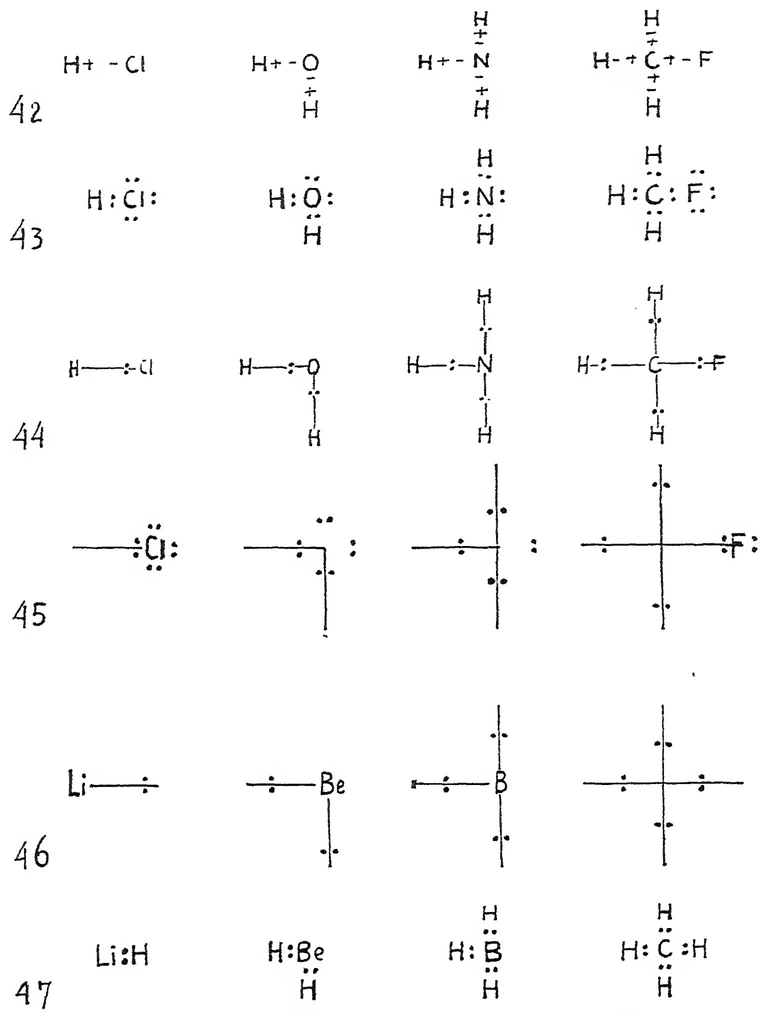

PLATE 5. ELECTROSTATIC OR POLAR BOND

42, Berzelius symbols of electrostatic affinity. 43, 47, Lewis octet formula. 44, Kharash polarity formula. 45, 46, electronic structure symbols.

trolysis and thereby drew the attention of the chemical world to the electric forces residing in molecules. These led Berzelius in 1812 to conceive an electrostatic nature of the bond between the atoms; one atom was positive, the other negative. To express his ideas in the simplest manner, he substituted for Dalton's geometrical symbols the initial letter or letters of the element and thus initiated the modern notation. Small positive and negative signs indicated the electric nature of the atoms (Fig. 42).

Polar Bond

The electrostatic bond of Berzelius has become the polar bond of Lewis, Kossel and others and is expressed in the Lewis octet formula (Figs. 43, 47) in which the valence electrons are pictured as dots. Thus in HCl the chlorine atom with seven electrons completes its octet by forming a pair with the single electron of hydrogen; when HCl is dis-

solved in water, it ionizes, that is, the chlorine atom retains the electron in its octet and has thus one negative charge, while the hydrogen, devoid of its electron, assumes a positive charge. There is a difference in the degree of this electrostatic or polar bond in different compounds, hence Kharasch and Reinmuth[2] developed a polarity formula (Fig. 44) which indicates the relative positiveness or negativeness of the atom by the distance of the electron pair from it. The electronic structure sym-

[2] *Jour. Chem. Ed.*, 5: 404–18, April, 1928; 8: 1703–48, September, 1931; and 11: 82–96, February, 1934.

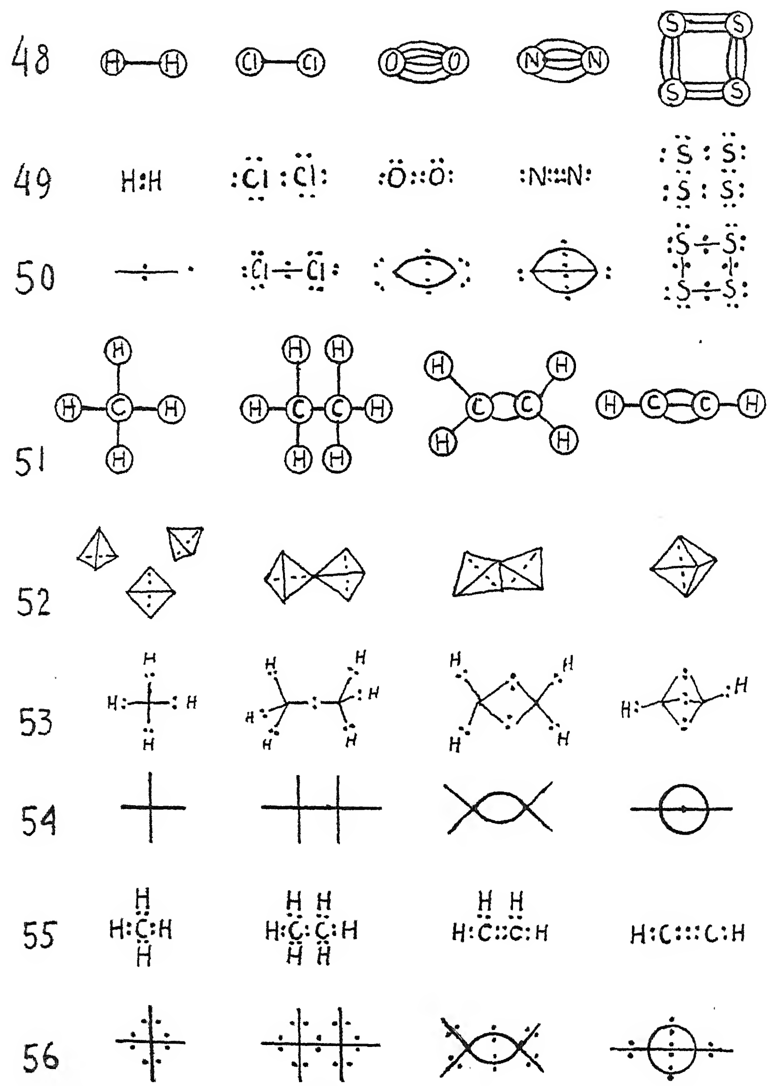

PLATE 6. GRAPHIC FORMULAS FOR THE NON-POLAR BOND
48, 51, GRAPHIC NOTATION OF KEKULE, FRANKLAND AND OTHERS. 49, 55, LEWIS OCTET FORMULAS. 50, 54, 56, STRUCTURE SYMBOLS. 52, TETRAHEDRAL CARBON ATOM OF VAN 'T HOFF, LEBEL AND WISLICENUS. 53, VECTOR SYMBOLS OF THE CARBON ATOM.

bols[3] (Figs. 45, 46) combine the advantages of the Lewis and Kharasch-Reinmuth notation by showing the polarity of the molecule by the position of the electron pairs. The more unshared electrons there are, as in Cl and O, the more negative the atom and the more polar the molecule, and *vice versa.* This is shown by a comparison of the hydrogen compounds of the elements of the first group of the periodic system; here the diameter of the octet increases steadily in passing from HCl to H_2O to NH_3 and CH_4. In Fig. 46 the hydrogen becomes less negative in going from LiH to BeH_2 to BH_3 and CH_4, which can be seen by drawing a line through the electron pairs of these respective compounds. In the case of methane, however, neither carbon nor hydrogen is negative or positive—the electron pair is located halfway between the atoms, both of which share them equally and constitute a non-polar bond.

Non-polar Bond

The synthesis of urea in 1828 by Friedrich Wöhler (1800–1882) marked the beginning of organic chemistry. The discovery that *organic* compounds can be made synthetically and without the aid of *vital* force led many chemists to investigate these interesting substances. It was only natural that many organic compounds were isolated which could not be explained by *electrostatic* bonds—the atoms were held together by some force upon which the electric current had no effect. Edward Frankland (1825–1899) and Adolph Wilhelm Hermann Kolbe (1818–1884) developed the theory of radicals during the middle part of the century and August Friedrich Kekulé (1829–1896) proposed the theory that carbon is tetravalent and has the greatest affinity for another carbon atom (1857), hence organic compounds are due to carbon-carbon bonds. In 1859 he proposed the ring structure for *hexamethin* (benzene) and thus laid the foundation for the study of aromatic compounds. The valences of carbon were shown by straight or curved lines as in the Frankland symbols (Figs. 48, 51) or the structure formulas of to-day, where we consider these bonds as non-polar or homopolar. This non-polar bond is shown in the electronic structure symbols (Figs. 50, 56) by placing the electron pair in the middle of the lines connecting the atoms.

Organic compounds, however, introduced the problem of isomerism, hence Jules A. Lebel (1847–18—) and Jacobus Hendricus van't Hoff (1852–1911) independently of each other considered the spacial arrangement of the tetrahedral carbon atom (1877). Ten years later (1887) Johannes Wislicenus (1835–1902) published his fundamental investigation on lactic acid which opened the field of optical isomerism and led to the geometrical formulas (Fig. 52). To project a space-model upon a plane surface involves difficulties, for many angles of perspective may be chosen. In Fig. 52 the carbon tetrahedron is shown respectively standing on one of its surfaces, its edges and its corner. It is the third projection which is assumed in structure symbols and represented by a cross (Fig. 54), where the horizontal arm would reach above the surface, the perpendicular arm be inclined below the paper surface. The single, double and triple C-C bond are also shown.

Instead of picturing the carbon atom as a tetrahedron the bonds may be thought of as vectors pointing from the center in the direction of the four corners of a tetrahedron. These vector formulas (Fig. 53) lead likewise to the electronic structure symbols (Fig. 56), where the non-polar bond is indicated

[3] Structure symbols are the structural formulas without the letters H, O, N and C, for as these elements have respectively a valency of 1, 2, 3 (or 5) and 4, they are indicated by points from which 1, 2, 3 (or 5) and 4 lines radiate. For bibliography see: Hackh, "Structure Symbols of Organic Compounds," vi, 139 pp., Philadelphia, P. Blakiston's Son and Co., 1931.

57, 58, 59, 60, 61, 62

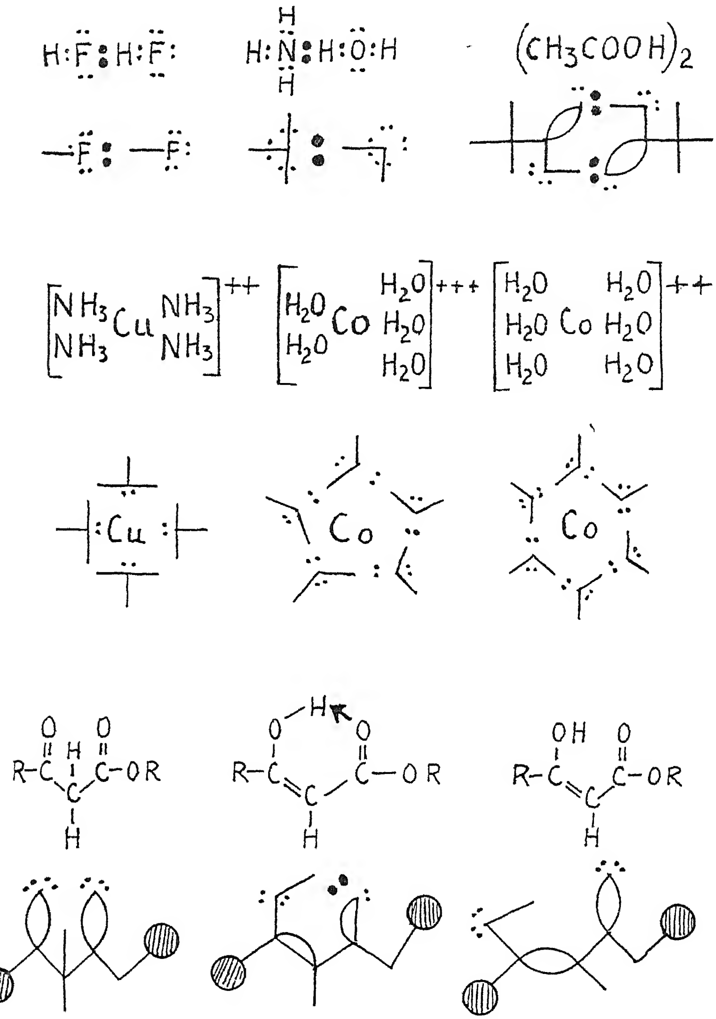

PLATE 7. MISCELLANEOUS TYPES OF BONDS

57, 58, ASSOCIATED MOLECULES. 59, 60, WERNER'S COORDINATE BOND FORMULA AND THE CORRESPONDING STRUCTURE SYMBOLS. 61, 62, SIDGWICK'S CHELATED COMPOUNDS AND THE CORRESPONDING STRUCTURE SYMBOLS.

by the electron pair being placed in the middle of each line.

Coordinate Bonds

Near the end of the century there were a number of facts known about the molecules which fitted neither the polar nor the non-polar type of bond. In 1900 Alfred Werner[4] (1866–1919) developed a theory of coordinate compounds and indicated these by the coordination formula (Fig. 59) which may be graphically depicted by the structure symbols (Fig. 60) where the water or ammonia molecules are *oriented* around the cobalt or copper atom.

Associated Molecules

So called *divalent* hydrogen resolves itself into a pair of oriented molecules where a hydrogen atom (in a very polar

[4] The portrait of Alfred Werner in the "Chemical Dictionary" (Blakiston's, Phila.) is erroneously labeled "Paul Sabatier," while Sabatier carries the legend "Alfred Werner."

compound) shares a free electron pair of a negative element. This coordinate bond is shown by the heavier dots in the Lewis symbols (Fig. 57) and the electronic structure symbols (Fig. 58). In the same class belongs the double molecule of acetic acid $(CH_3COOH)_2$, said to exist in aqueous solutions.

Chelated Bonds

The *chelated* compounds of Sidgwick[5] differ from associated molecules merely in having within *one* molecule the possibility of *divalent* hydrogen, that is, the possibility of the hydrogen sharing a free electron pair. Thus in the ketone-enol isomerism (Fig. 61) the position of the hydrogen, near two oxygen atoms, is such that it can alternately share the electron pair with the two oxygen or the carbon. The arrow indicates the *chelated* oxygen, while in the structure symbols (Fig. 62) the static and dynamic forms of ketone, ketone-alcohol and alcohol are shown.

Divided Valence

To indicate a *divided* bond, as in the –COOH group where the hydrogen is bound equally strong to *either* oxygen atom, it has been proposed to mark this by a dotted valence line (Fig. 63c). However, as this appears to be a dynamic isomerism, that is, a rapid oscillation of the electron pair or bond from position a to b to a, etc., the static structure symbol (Fig. 64) is either a or b, while the dynamic symbol is shown in c.

Abnormal Valence

Higher or lower valence than normal resolves itself into a coordinate bond. Thus the tetravalent oxygen in ester hydrochlorides (Fig. 65) is represented by the structure symbol (Fig. 66), where the heavy dots indicate the bond between the oxygen and the hydrogen of the oriented HCl molecule.

[5] Sidgwick, *Jour. Chem. Soc.*, 127: 907 (1925), "Electronic Theory of Valence," Oxford, 1927.

Benzene Ring

The structure of the benzene ring has occupied the attention of chemists ever since 1865, when Kekulé developed the common hexagon formula with three single and three double bonds between the six carbon atoms. But this static formula predicts that there should be two ortho, two meta and two para substitute compounds, whereas only one of each is known. Hence many attempts have been made to find a structure which makes the six carbon atoms equal to each other. Claus (1867) suggested a *diagonal* formula, resembling Fig. 67b, Ladenburg (1869) proposed the *prism* formula, Claus again (1870) the *bridge* formula, Armstrong and Baeyer (1892) a *centric* formula, where the fourth valence merely points toward the center of the ring, Thiele and others developed a *split valence* formula (Fig. 67a) and in more recent times Koerner developed a centroid arrangement of six tetrahedrons in alternately different planes. Pauling's *dynamic* formula conceives the electrons in elliptical orbits, and Huggins pictures three *oscillating* or shifting electron pairs in the center of the ring. The dynamic concept of the benzene ring is shown by the two structure symbols (Fig. 68) where the electrons are placed equally distant from all six carbon atoms, and it is thus immaterial from the position of the dots whether the double bond joins carbon 6 and 1, or carbon 1 and 2, etc. We may picture the benzene ring as constantly shifting between these two symbols, that is, an oscillating and rotating double bond, as illustrated by the mechanical benzene model.

Benzene Substitutions

If a negative or positive atom or radical substitutes one of the hydrogen atom of the benzene ring, an electron shift will occur, according to the electron formula of Lucas (Fig. 69) where the small rings indicate the electron

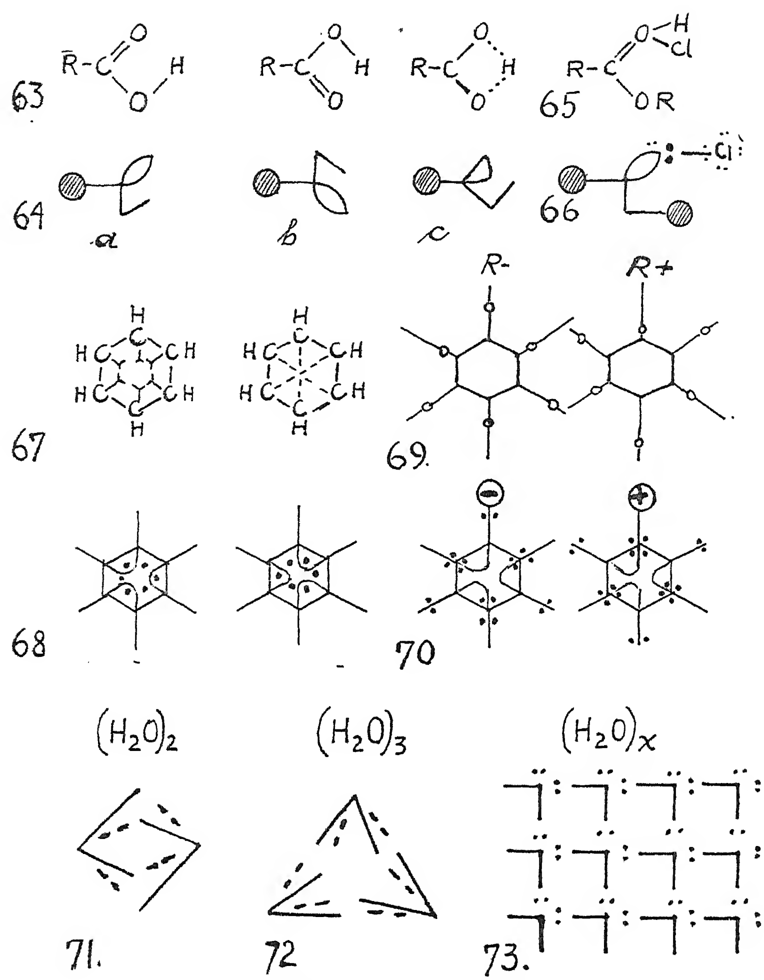

PLATE 8. MISCELLANEOUS NOTATIONS

63, 64, TAUTOMERISM OF THE –COOH GROUP WHICH ASSUMES A DIVIDED VALENCE FOR THE H-ATOM. 65, 66, TETRAVALENCE OF OXYGEN IN ESTERS WHERE THE KETO-OXYGEN IS ASSUMED TO FORM AN ADDITION COMPOUND WITH HCl. 67, 68, VARIOUS FORMS OF THE BENZENE RING. 69, 70, LUCAS POLARITY FORMULA AND THE CORRESPONDING STRUCTURE SYMBOLS FOR SUBSTITUTED BENZENE RING. 71, 72, STRUCTURE SYMBOL FOR DIHYDROL AND TRIHYDROL. 73, STRUCTURE SYMBOL FOR THE SPACE LATTICE OF ICE.

pair. Thus a negative atom or radical pulls the electron pair from carbon 1, which thus becomes positive. This results in carbons 2 and 6 as well as 4 becoming negative; while 3 and 5 become negative. Should the radical be positive, the reverse polarization takes place. The corresponding structure symbols are shown in Fig. 70.

Water and Ice

According to its temperature, water consists of varying percentages of monohydrol, H_2O; dihydrol, $(H_2O)_2$, and trihydrol, $(H_2O)_3$. Cold water has more trihydrol, hot water more monohydrol, the dihydrol present in approximately 50 per cent. These two associ-

ated molecules are shown in Figs. 71 and 72, where each hydrogen is held also by a coordinate bond to another molecule; it shares the free electron pair of the oxygen of its opposing molecule. (The electron pairs have been elongated in the symbol to show direction.)

Ice has a crystal lattice of an oxygen atom surrounded by four hydrogen atoms. This space lattice is shown on a plane surface by structure symbol 73, where only the free electron pairs are (conventionally) shown. To make the picture complete, it must be considered dynamic, that is, the lines indicating the H-O bonds will swing around, as the hydrogen and oxygen kernels oscillate or wiggle, according to their temperature, until they finally melt and form trihydrol and dihydrol associations.

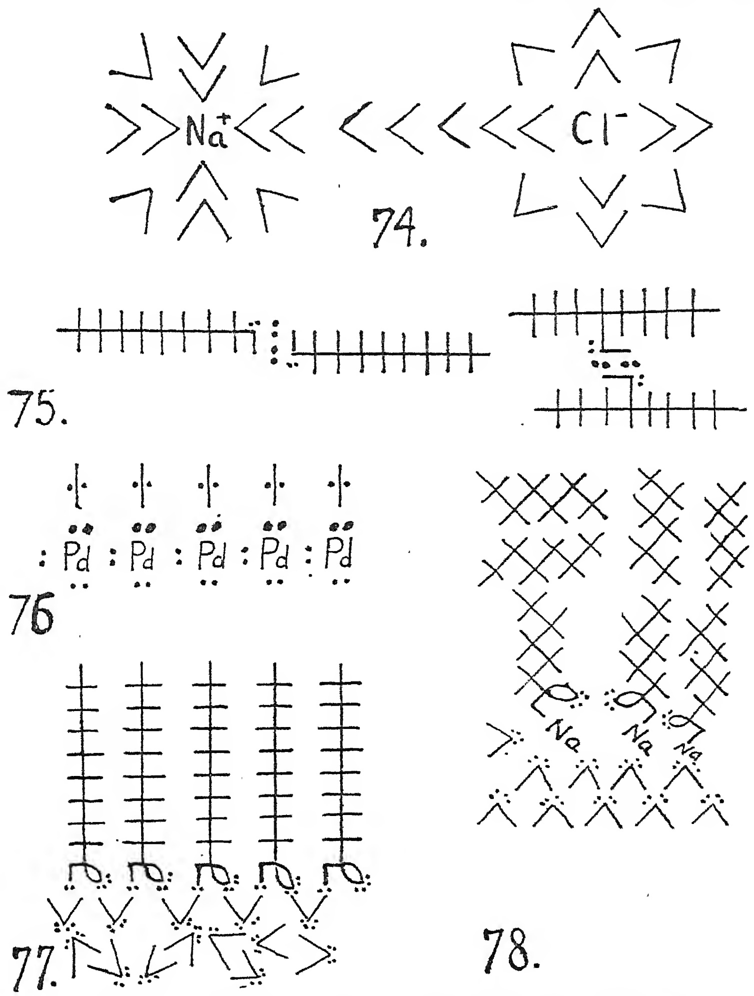

PLATE 9. VARIOUS USES OF STRUCTURE SYMBOLS

74, SOLVATED IONS WITH ORIENTED WATER MOLECULES. 75, CYBOTAXIS OR LENGTHWISE AND SIDEWISE ASSOCIATION OF TWO OCTANOL MOLECULES (1-HYDROXY- AND 4-HYDROXY-OCTANE, RESPECTIVELY). 76, ADSORPTION OF H_2 MOLECULES ON A PALLADIUM SURFACE. 77, ORIENTATION OF FATTY ACID MOLECULES ON WATER SURFACE. 78, SECTION THROUGH A COLLOID: HEXANE-SOAP-WATER.

Solvation and Ionization

When a polar compound like NaCl is dissolved in water it ionizes and forms Na^+ and Cl^- ions. The more negative or positive the elements, the higher the degree of dissociation. This can be visualized by structure symbol 74, which shows that the water molecules are oriented around the sodium or chlorine kernels; the oxygen of the water points toward the positive ion, while the hydrogen points toward the negative ion. Such layers of oriented molecules probably act as buffers, and the entire group moves as a particle or micelle through the water.

Surface Adsorption

If hydrogen gas is brought in contact with a palladium or platinum surface the electron layer of the metal will attract the hydrogen molecules, and these will orient themselves upon the metal surface as shown in Fig. 76. The hydrogen condenses practically to a solid, thereby liberating heat (which has been utilized in Doebereiner's fire machine and the modern gas lighters using platinized asbestos).

Monomolecular Films

A layer of a fatty acid upon water is shown in Fig. 77, where the polar –COOH groups dip into the water, while the non-polar hydrocarbon ends of the fatty acid point away.

Cybotaxis

Cybotaxis is the oriented association of similar molecules; thus 1-octanol arranges itself lengthwise (Fig. 75), while 4-octanol is oriented sidewise.

Colloids

Orientation likewise plays a large rôle in colloidal systems; thus a cross-section through the boundary between hydrocarbon-soap-water is shown in Fig. 78. The non-polar hydrocarbon is a normal or non-associated liquid which possesses no *unshared* electron pairs, while water is a highly polar or associated liquid, having many unshared electron pairs. Between these two liquids the molecules of the protective colloid arrange themselves so that their polar end points into the polar liquid (water), their non-polar end into the non-polar liquid (hydrocarbon).

Free Radicals

A free radical is indicated in the Lewis notation by an unfinished octet, thus tri-R-methane or di-R-nitrogen lack both one electron to complete the octet (Fig. 79) and the corresponding structure symbols (Fig. 80) show the single electron as a heavier dot on a dotted line. The dotted line is the conventional indication of the valence bonds necessary to show a particular atom, four lines for carbon, three for nitrogen, etc. If the line were solid it would indicate a hydrogen atom at the end of it.

Active Compounds

Some molecules may exist in an active and inactive form; thus for formaldehyde there are assumed the two types shown in Figs. 81 and 82, where the active form is indicated by the two single electrons; the aldehyde structure has become an alcohol structure. The dotted line indicates the free valence.

Addition Compounds

Coordinated and associated molecules as well as the solvated ions may be considered as addition compounds of varying degree. In each case the positive atom (without free or unshared electrons) shares the electron pair supplied by a negative atom. An example of an organic addition compound is boron trichloride di-R-oxide (Figs. 83, 84), which according to the older concept requires tetravalent boron and trivalent oxygen, but which reveals itself as an oriented molecule in which the positive boron shares the electron pair of the oxygen atom, as shown in structure sym-

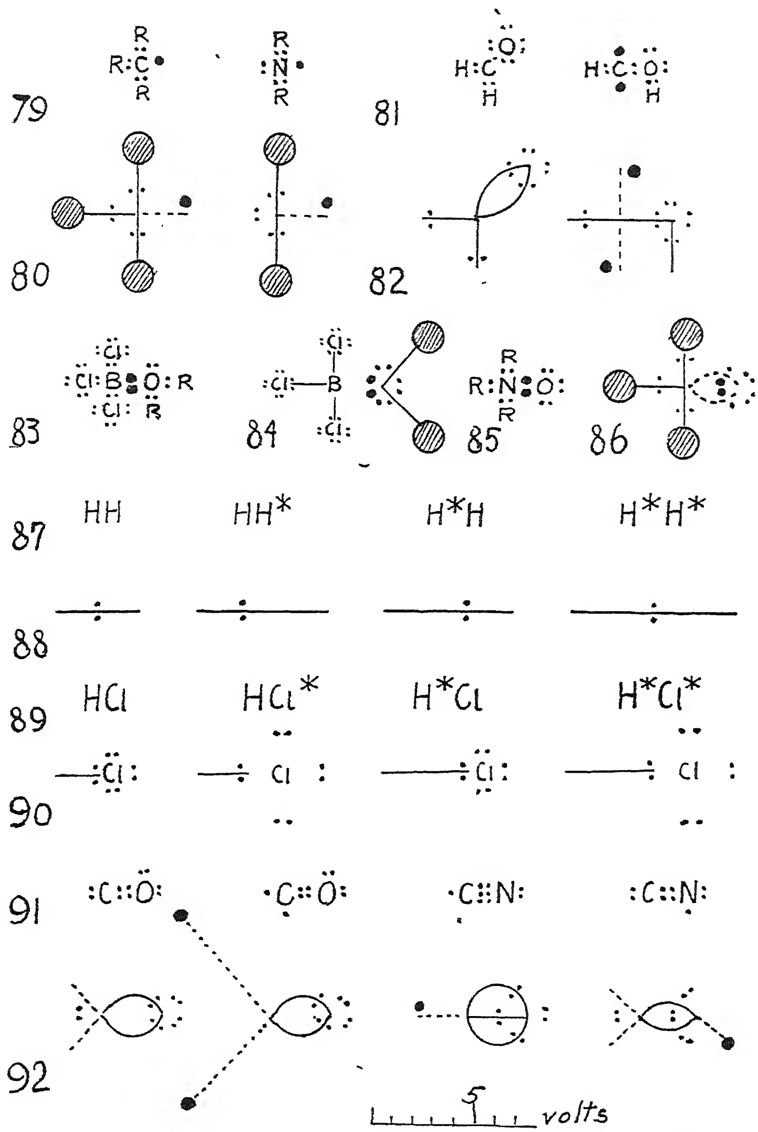

PLATE 10. OTHER APPLICATIONS OF STRUCTURE SYMBOLS

79, 80, FREE RADICALS: TRI-R-METHANE AND DI-R-NITROGEN. 81, 82, INACTIVE AND ACTIVE COMPOUNDS: FORMALDEHYDE. 83, 84, ADDITION COMPOUNDS: TRICHLOROBORON DI-R-OXIDE. 85, 86, TRI-R-AMINE-OXIDE. 87, 88, EXCITATION: HYDROGEN MOLECULE. 89, 90, EXCITATION: HYDROCHLORIC ACID. 91, 92, NORMAL AND EXCITED MOLECULES: CO AND CN.

bol 84. Similar is the structure of amine oxides (Figs. 85, 86), where nitrogen shares the free electron pair of an oxygen atom.

Excitation and Irradiation

Atoms or molecules may absorb certain quanta of light energy and become excited, that is, their electrons move in higher energy levels. Excited atoms are indicated in the ordinary formula by an asterisk (*), as in Figs. 87 and 89, while in structure symbols the length of the lines or the size of the electron octet

may show the state of excitation (Figs. 88 and 90). If more definite information is known as to the distribution of the electrons in the normal and excited state, the structure symbols may be used as energy diagrams (Fig. 92). Thus Pauling[6] determines for the normal and excited state of CO and CN the electron distribution shown by the Lewis symbols (Fig. 91) and an energy difference of 5.96 and 1.78 volts, respectively. These changes are graphically shown in Fig. 92, where the distance of the electron from the atom is proportional to the force. In the CN radical a shift of an electron pair occurs.

Isotopic Compounds

The discovery of heavy hydrogen (deuterium, diplogen, *b*-hydrogen, H^2 or H^b), together with the oxygen isotopes, gives nine possible water molecules (Figs. 93 and 94), which have among several other proposed names the following:

[6] Pauling, *Jour. Amer. Chem. Soc.*, 53: 1367, 1931.

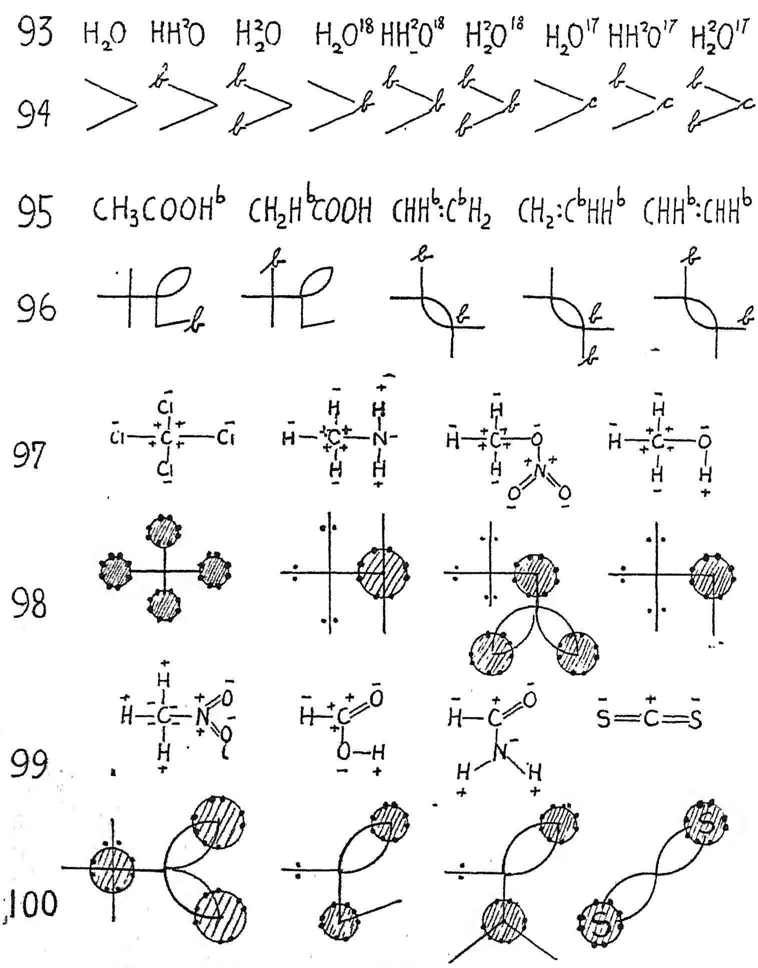

PLATE 11. ISOTOPIC COMPOUNDS AND POLARITY

93, 94, ISOTOPES OF WATER. 95, 96, ISOTOPIC COMPOUNDS: TYPES OF ACETIC ACID AND ETHYLENE. 97, 99, POLARITY FORMULAS. 98, 100, STRUCTURE SYMBOL DIAGRAMS FOR ELECTRICALLY SYMMETRIC AND ASYMMETRIC COMPOUNDS. (NEGATIVE AREA IS SHADED.) DIELECTRIC CONSTANT INCREASES FROM CCl_4 TO $HCONH_2$.

	Proposed Name[7]
diprotium oxide	hydrogen oxide
mono-deuterium oxide	*b*-hydrogen oxide
di-deuterium oxide	*bb*-hydrogen oxide
diprotium heptadecanide	hydrogen-*b*-oxide
mono-deuterium heptadecanide	*b*-hydrogen-*b*-oxide
di-deuterium heptadecanide	*bb*-hydrogen-*b*-oxide
diprotium octodecanide	hydrogen-*c*-oxide
mono-deuterium octodecanide	*b*-hydrogen-*c*-oxide
di-deuterium octodecanide	*bb*-hydrogen-*c*-oxide

The apparently limitless possibilities of isotopic compounds in organic chemistry is indicated by the fact that there are possible 288 different acetic acids or 20, 968, 879, 178, 648 normal stearic acids, with two isotopes of hydrogen, two of carbon and three of oxygen. Thus with the two hydrogen isotopes alone there are the following eight acetic acids:

CH_3COOH CH_2H^bCOOH CHH^b_2COOH CH^b_3COOH

CH_3COOH^b $CH_2H^bCOOH^b$ $CHH^b_2COOH^b$ $CH^b_3COOH^b$

The terminology of these isotopic compounds will be so complex that their formulas (Figs. 95, 96) apparently are the simplest means of identification. In the case of ethylene, $CHH^b:CHH^b$, there should exist a cis- as well as trans-isotopic form.

Dielectric Constant

The specific inductive capacity of a liquid depends upon the electrical symmetry of the molecules composing it. If the negative charges are symmetrically located in space and equally distributed in respect to the positive charges, the dielectric constant is low, as in CCl_4 or CS_2. If one or more chlorine atoms of CCl_4 are replaced by hydrogen, the molecule becomes electrically asymmetric, for the negative charges (chlorine atoms) are unevenly distributed on the corners of a tetrahedron. The greater this asymmetry, the higher the dielectric constant. The polarity formulas (Figs. 97, 99) are arranged so that from CCl_4 to $H \cdot CO \cdot NH_2$ the dielectric constant increases, hence these compounds show an increasing electric asymmetry. In the structure symbols (Figs. 98, 100) this increasing electric asymmetry is shown by shading the negative areas. Projecting these symbols into three dimensions will naturally show the electrical symmetry conditions to better advantage, for in the case of $H \cdot CO \cdot OH$ the two oxygens are in one plane, or on two corners of the tetrahedron, which makes thus the molecule lop-sided.

Polarization

While the polarity formula indicates the dipole nature of the molecule, that is, the distribution of electrical charges within the molecule, the polarization formula shows the changes within the molecule in respect to its surrounding. Thus, in the case of water, where the distance of hydrogen to oxygen is 0.96 ångstrom units and the angle of hydrogen-oxygen-hydrogen is 105° (Fig. 101), an electric field may distort and displace the atoms as follows:

Electronic polarization, where the electrons are displaced with respect to the positive nucleus, as in 102a.

Atomic polarization, where the atoms are displaced, or the molecule is distorted, as in 102b.

Molecular polarization, or orientation of the molecule, as in 102c. In Fig. 102d, e and f, a combination of these three types of polarization is shown.

Isosteres and Electronic Constellations

Isosteres are sets of compounds with similar electronic constellation, that is,

[7] Following the suggestion of *Terminologist* in naming isotopic compounds: *Science*, 79: 505, June 1, 1934.

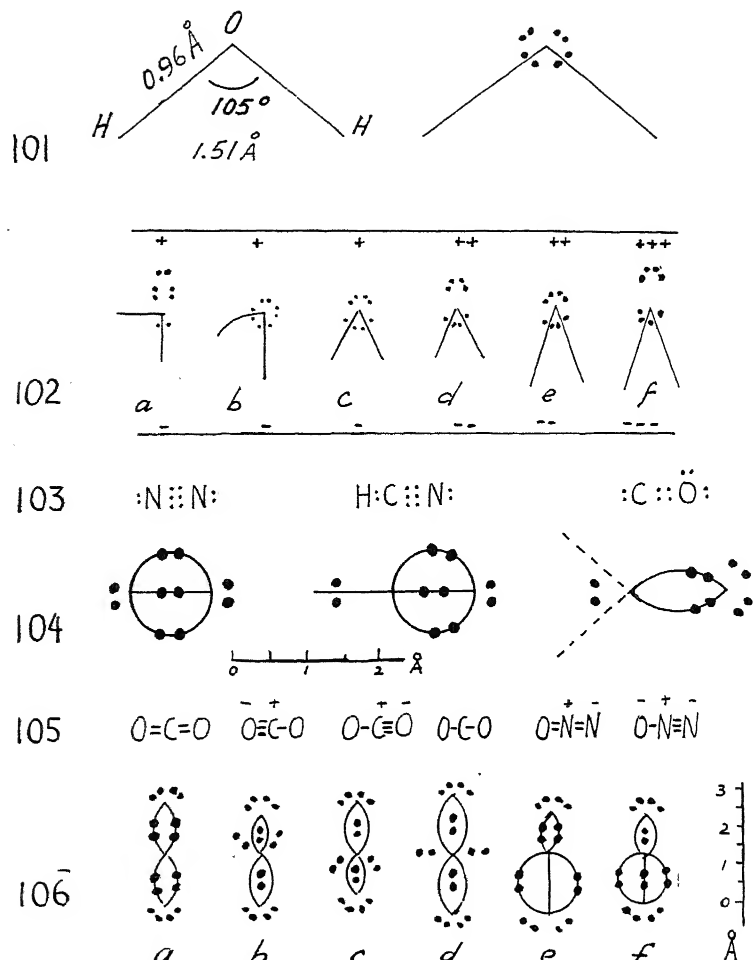

PLATE 12. POLARIZATION AND ELECTRONIC CONSTELLATIONS

101, WATER MOLECULE DRAWN TO SCALE. 102, POLARIZATION: A, ELECTRON DISPLACEMENT; B, ATOM DISPLACEMENT; C, MOLECULE DISPLACEMENT (ORIENTATION); D, E, F, COMBINATIONS. 103, 104, ELECTRONIC CONSTELLATIONS: THE ISOSTERES OF NITROGEN, HYDROCYANIC ACID AND CARBON MONOXIDE. 105, 106, ELECTRONIC CONSTELLATIONS: THE SHIFTING ELECTRON PAIRS OF CARBON DIOXIDE AND NITROUS OXIDE.

similar configuration of the electrons. Thus nitrogen, hydrocyanic acid and carbon monoxide have each ten electrons (Figs. 103 and 104) and similar physical and biological properties. Their molecules are drawn to scale in the structure symbols 104, where the similarity of HCN and CO is indicated by the octet and single pair of electrons.

In the case of carbon dioxide and nitrous oxide there are, according to Pauling, various electronic constellations possible, which probably all exist and form in rapid succession. As the atomic kernels oscillate, the electrons shift. Thus the distance of the C = O bond is 1.28 ångstroms, that of the C ≡ O 1.13 å. The alternate shortening

and lengthening of the distance between the atomic nuclei causes the electron pairs moving from positions shown in 106a, b, c and d, for carbon dioxide, and a similar number of positions for nitrous oxide, of which only two, Figs. 106e and f, are shown. It will be noticed that a and e, as well as c and f, are similar constellations.

Summary

The evolution of the chemical symbols is an interesting chapter of chemistry and illustrates the attempts of the human mind to represent its concept of facts and fancy in a concise and generally pictorial way. Beginning with the ideogrammatic hieroglyphs it has passed through the allegorical symbolism of the alchemists and emerged into the simple notation of to-day.

The newer developments in physical and organic chemistry make it again desirable to use graphs and diagrams of the molecule. Structure symbols provide a simple means of showing qualitative (as diagram) or quantitative (as graph) the different types of bonds between the atoms, polarity and polarization, orientation, colloidal structures, atomic distances and electronic constellations, besides the more familiar structural relationships, as isomerism and the possible future compounds of isotopic carbon, hydrogen and oxygen.

In unifying the concept of atomic bonds the electronic structure symbols illustrate the three fundamental types of bonds as:

(1) *Ionizing* or *polar* bond (where the electron pair is held unequally; one atom becomes more negative, the other more positive)—by a pair of dots astride a line and displaced toward the negative end of a line;

(2) *Non-ionizing* or *homopolar* bond (where the electron pair is shared equally, neither atom becomes positive or negative)—by having a pair of dots astride a line and halfway between the end of the line indicating the bond; and

(3) *Coordinate* or *semipolar* bond (where a negative atom contributes both electrons which are shared, more or less firmly, by a positive atom)—by a pair of dots without a line indicating the bond.

BIOLOGICAL APPROACHES TO ANTHROPOLOGY

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ANTHROPOLOGY has developed through the study of such racial features as art and architecture, folk-lore, language and literature, religious beliefs and practises, work, play, social customs and warfare. To this has been added information gained from exact anatomical measurements. Recently certain biological sciences, other than anatomy, have contributed to the study of man, notably physiology, pathology and immunology. A brief review follows of certain data from these fields, and if more than a due share derives from work done in the Near East the explanation is the writer's former residence in that area.

In theory racial peculiarities are of two kinds. There are first those which result from environment. These any folk group might be expected ultimately to take on when confronted with the given environment. Secondly, are racial features based on fundamental genetic structure, which exist irrespective of wind, tide, temperature, rainfall, altitude or other environmental factors or combinations thereof. In practise the distinction is not always sharply to be made. Needless to say, racial features based on essential genetic structure are more useful to the anthropologist in tracing origins, migrations and relationships than those acquired in a given environment, possibly to be lost when that environment no longer exists.

The points first to be discussed partake somewhat of the nature of the first category. Of these, we list basal metabolism, vital capacity, blood pressure, pulse rate, visual and auditory acuity, muscular strength, age of onset of puberty and climacteric, dental conditions and various aspects of racial pathology.

Basal metabolism is an individual's minimal heat production measured fourteen to eighteen hours after eating, while at complete rest but not asleep. It represents energy expended to maintain respiration, circulation, peristalsis, muscle tonus, body temperature, glandular activity and other vegetative functions. It is measured with a calorimeter and its value is expressed in calories per hour per square meter of body surface. Certain standards have been set up as normal, such as those of Sanborn, of Harris and Benedict, of Dreyer and of Aub and Du Bois. An average value for basal metabolism is 40 calories per hour per square meter of surface. In racial studies it is customary to express the deviation from the normal in plus or minus percentages rather than to state the exact metabolism. Thus Heinbecker reported a +33 per cent. metabolism for Eskimos; Steggerda and Benedict a three-day average of +8.4 per cent. for male Maya Indians in Yucatan; Mason and Benedict a value of −17.2 per cent. for 54 women from South India, and Krishnan and Vareed somewhat similar low figures for women medical students at Madras. Nearly fifty papers on basal metabolism in different ethnic groups have been published. It will suffice to point out that with the exception of the Yucatan Maya Indians, groups living in tropical or subtropical areas show a lower basal metabolism than do white Westerners. It is well recognized that basal metabolism varies with age, sex and state of health. Type of diet may be a factor as in the Bengali, whose food is low in protein, fat and satisfactory vitamin and mineral content. Perhaps the generally low metabolic rate of the

Oriental derives from the fact that in rest his relaxation is more complete than that of the Occidental. Possibly the psychology of a fatalistic or other worldly people has something to do with it. Some writers have implicated the climate per se as a factor. Benedict, however, than whom none can speak more authoritatively, feels the different basal metabolism values obtained carry a racial factor.

In the Near East basal metabolism studies have been made by Turner at Beirut. He found the metabolic rate for Armenian males to approximate Aub and Du Bois' standards. This is just what one would expect, for the Armenian is Balkan rather than Asiatic. The lowest values Turner obtained in his first series on males were from Egyptians. The Arabic-speaking Syrian was below accepted standards but rated above the Egyptians. As illustrating the fundamental nature of the metabolic function two of Turner's controls were Americans of the second generation in the Syrian climate. This recalls Benedict's work with low metabolism Chinese and Japanese girls in America and the work of Blunt and Dye with a Japanese woman living under American conditions yet retaining her −14 per cent. Japanese metabolism.

Turner, assisted by Dr. Adma Aboushadid, found an average value of −13.3 per cent. for 24 of 28 Syrian girls typical of their race and higher values for one girl who was half English and for three whose physical appearance suggested European rather than Syrian antecedents. It is true that in this series the control group of women, American and European personnel, was somewhat below normal, but there was, notwithstanding, a marked difference between them and the twenty-four Syrian girls. Turner has recently affirmed his belief that the Syrian basal metabolism is 8 to 12 per cent. below accepted standards. He is inclined to feel that the possibility of a more complete relaxation is important in the explanation. The fact retains its value for racial characterization, even so.

Vital capacity refers to the number of cubic inches of air one can forcibly expire after a full inspiration. Texts put this at about 3,700 cc for the average adult white male. In America distinct vital capacity differences between whites and blacks have been noted by Wilson and Edwards, by Smillie and Augustine and by Roberts and Crabtree. The vital capacity of the Negro race in both sexes and at all ages studied is remarkably lower than that of the white. Studies on Chinese, Siamese, Filipinos and natives of India show likewise low vital capacity rates. Turner found Syrian vital capacity to be below standard. It is interesting to note that Schneider confirmed the belief of physiologists that lowering of the barometric pressure temporarily reduces vital capacity. Most of the folk groups with lowered vital capacity live at as high barometric pressure as do American whites. This is particularly true for Turner's groups, practically all of whom resided on the Syrian coast.

Blood pressure refers to the tension in the walls of the blood vessels occasioned by pulsations of the heart. Diastolic pressure is the pressure in millimeters of mercury in the brachial artery during diastole, which is the stage of dilation of the heart, especially of the ventricles. Systolic pressure, obviously greater than diastolic, is the pressure in the artery during systole or contraction of the ventricles which occurs at the time of the first heart sound as the blood is driven into the great aorta and the pulmonary artery. Diehl at Minnesota found a definite gradation in blood pressure from Filipinos, Chinese and Japanese up through Negroes to Americans and Scandinavians. Roddis and Cooper studied army officers under tropical and temperate zone conditions of residence

and concluded that low blood pressure in the tropics is primarily due to altered physical activity. This point is supported by the survey of a prison population of 6,400 by Alvarez and Stanley, who noted failure of blood pressure findings to show changes with age anticipated in the usual normal population. Turner states that Syrian blood pressure probably averages slightly lower than that for American whites, but he is not inclined to give much weight to this difference. It is, however, significant that diseases of high blood pressure are not as common among natives of low blood pressure areas as elsewhere, although in those areas persons of other races may and do exhibit hypertension.

Another physiological feature more easily determined but much harder to interpret racially is pulse rate. Syrian pulse rate is said by Turner to be practically normal. Hrdlička states that slow pulse rate is an Indian characteristic, and it has been particularly called to our attention in the high basal metabolism Yucatan Mayas that their pulse rate is low.

Bunch and Raiford have studied auditory acuity among whites and blacks in the United States. They noted certain differences. Such studies should be extended and might well include visual acuity, apart from color vision. Lefrou reports that blacks of Equatorial Africa are less vividly impressed by the light used in ophthalmoscopic examination and can fix their attention on points in space with less fatigue than can whites. He tells of laboratory aides who diagnosed relapsing fever spirochetes in fresh blood preparations under powers of the microscope which revealed absolutely nothing to him and his European colleagues. He was of opinion that this was because of a better appreciation of the movement of particles rather than a question of unusual powers of vision, although he does make incidental reference to some fundamental racial eye structure differences, a point which should be checked.

It is common knowledge that the onset of puberty and the climacteric are physiological factors which vary under different conditions of race and environment. In some tropical countries early marriages, at which we are so shocked, derive their local sanction from the early onset of puberty and the belief amongst the people that child-bearing should begin shortly after the sexual functions are established. One standard text states: "Heredity is also a determining factor, and experience demonstrates that girls of Latin extraction develop into womanhood earlier than those of Anglo-Saxon descent." Limits for the average onset of menstruation as commonly set vary from nine years in the tropics to sixteen or seventeen years in the north. The justice of nature to the individual woman is hard to understand when we realize that, all else being equal, early menstruation means late menopause, although the working out of this order of things on the whole is rational, with mass production and destruction in the tropics and lessened production and destruction in the north.

Conditions of the teeth have long been noted as racial characteristics and believed by many to have some inherent genetic background. Teeth are, of course, much influenced by nutrition and other environmental factors. The excellence of the teeth of many peasant peoples of Africa and Asia is as well known as the defectiveness of the English teeth is notorious.

In an interesting comment on anthropology and medicine in one of the older Systems of Medicine, Beddoe points out that by analogy with animals different races of men should present quite different pictures of pathology. Before it was known that many diseases were communicable and caused by parasite, bacterium or virus, many very striking racial disease peculiarities were recorded.

With the advent of the concept of the direct or indirect microbic etiology of most of our important diseases emphasis on racial differences in disease has been transferred from man's racial contribution to the microbes' geographical distribution. Probably it would be wiser to include both man and microbe in such considerations.

In the light of the recent development of knowledge concerning bacterial variation, we are now more than ever in position to understand that disease incited by living agents is variable. A change in type in a given disease can in some instances be observed within a lifetime (*cf.* scarlet fever) and while there is more or less of cyclic nature to rises and falls of virulence, to epidemics and to absence of epidemics, it seems true that a given disease as studied by one generation will differ somewhat from that seen by another. If we can determine foci of antiquity for a disease, as contrasted with areas where it is new, differences will be observed in the way it attacks people, which should interest the anthropologist. That these matters are not easy to decide is well illustrated by the controversy of syphilologists as to whether syphilis existed in American Indians before Columbus' time, whether yaws is syphilis and whether the pandemic "bejel" of the Arab, as reported by Ellis Hudson, is syphilis.

A classical example of the difference between the action of a disease new to an area and one old to it is afforded by tuberculosis. We measure the extent of tubercularization of a race by the type of tuberculosis it has and by the percentage of tuberculin reactors present in the population. The tuberculin reaction elicits a positive reaction in those with sensitization to the tubercle. The number of positive results varies from nearly zero in natives of the Sudan and similar primitive peoples to 100 per cent. in adults of the working classes in such a place as Oslo (Heimbeck). Goodale and Krischner examined 944 Syrians and Armenians at Beirut and found only 47.6 per cent. tuberculin positive. At Beirut, also, Goodale analyzed 1,150 cases of tuberculosis and found that the non-pulmonary type (bone and joint tuberculosis, particularly) exceeded the pulmonary types by 738 cases to 412. The Near Easterners are then midway between the primitive and the race-adult type of tuberculosis.

It is quite impossible here to enumerate the numerous very interesting examples of the racial aspects of disease. Racial pathology is being developed extensively in Europe under Askanazy and in America, particularly in its tropical diseases aspect by a committee of the National Research Council directed by McKinley. It will suffice here to insist that this material, usually considered only of interest to medical men, has much in it of value for the anthropologist and to include one or two more references to the Near East.

The scarcity of diphtheria, and particularly scarlet fever, in warm countries has been remarked by many observers and is quite in contrast to the universal distribution of measles. Oddly, not only are these diseases uncommon in those areas but susceptibility to them is low. The Dick test presumably reveals susceptibility to scarlet fever. Parr, Goodale and Krischner applied it to 714 Near Easterners at Beirut and found but 6.4 per cent. positive or susceptible to scarlet fever, whereas of 38 Anglo-Americans tested at the same time 57.8 per cent. were positive. The Schick test reveals susceptibility to diphtheria. It was applied at Beirut by Parr, Goodale and Krischner to 878 local inhabitants, of whom 3.9 per cent. were found susceptible, whereas of 49 Anglo-Americans tested 28.5 per cent. were positive. Fletcher and others have suggested that the microbes causing these diseases are present in the environment, are nonvirulent but antigenic, and evoke early

immunity through wide-spread subclinical infection. While this may well be the explanation, some investigators toy with the yet unestablished hypothesis that antibodies to certain diseases, at least, may be considered as maturing more or less naturally. The finding of diphtheria antitoxin in Polar Eskimos by Heinbecker and Irvine-Jones and by Bay-Schmith in the proven absence of diphtheria bacillus illustrates with anthropological interest the type of reasoning at the basis of this "maturation hypothesis."

Parr at Beirut noted the low puerperal sepsis rate in obstetrical wards of hospitals, despite the very poor risks offered the obstetrician. He suggested that this resistance to puerperal sepsis might be correlated with inborn, or at least existing, resistance to scarlet fever, as measured by the rarity of the disease and the low percentage of positive Dick test reactors. Scarlet fever and most puerperal sepsis are caused by streptococci.

We may now consider some racial features of biological nature which are presumably more inherent in the genetic structure of the individual than those mentioned. First, we may say that but few diseased conditions are of this category. Not many partake of the singular racial aspect of Buerger's syndrome, thrombo-angiitis-obliterans, which attacks middle-aged male Hebrews from Central Europe almost exclusively.

Atopic manifestations, as illustrated by hay fever, are rare in the Near East, although Americans subject to hay fever at home may suffer from it in Syria. One of them (Kerr) reports that he has never encountered a pure Syrian subject to hay fever.

In his excellent treatise on color vision Sir John Herbert Parsons states the color sense of the Egyptian to be not altogether accurate. One way anthropologists arrive at a knowledge of the color life of a people is from a study of their language. The evolution of the color sense in man has thus been traced. There is some question as to the accuracy of this method. Although the Arabic language has a rich color vocabulary, tests made with colored materials have shown that these terms are applied very loosely, in Egypt brown being more often misnamed than any other color. In discussing the racial aspects of color blindness, Clements states that the percentage of color-blind in Egypt is five, a figure intermediate between the high value of 12.8 per cent. for the Todas and the low values of 0.2 per cent. and 0.8 per cent. for the Malays and Eskimos, respectively. Color blindness is a recessive sex-linked character probably due to multiple factors and is naturally more common in males than in females. There are different kinds of color blindness, and it has been determined in a variety of ways. It is easy therefore to understand that the figures of the past leave much to be desired.

A tabulation is offered showing color blindness in males as revealed by the Ishihara test. These data derive from recent publications by Clements, Kilborn and Beh, and Garth.

	Number tested	Color blind	Per cent.
Europeans and white Americans	4,529	367	8.1
Chinese	2,279	147	6.4
Jew (United States)	200	8	4.0
American Negroes	1,115	40	3.5
Mexicans	1,094	26	2.3
American Indians	1,721	32	1.8

A study on color blindness in Syria by Appelrot is at present in progress. Clements feels color blindness racial differences are significant, whereas Garth expresses a question.

Medical missionaries are quite familiar with the fact that standards of drug dosage for their constituents are different from those they were taught, usually varying in the larger dosages employed. A phenomenon of pharma-

cology with more racial significance than this has been reported by Chen and Poth under the heading, "Racial Differences Illustrated by Mydriatics," in which they review the meager previous work on the subject and add their own findings. They studied the pupil-dilating action in the eyes of 10 Caucasians, 10 Negroes and 10 Chinese of five drugs—cocaine, euphthalmine, l-ephedrine, dl-ephedrine and d-pseudo-ephedrine—and distinctly found that the Caucasians were most and Negroes least susceptible to the mydriatic action of the drugs under investigation, the Chinese being intermediate. It is not a question of differential response to drug action on a physiological basis in the same way that an Egyptian requires more castor oil than a Frenchman, for other parts of the body in these three races do not show such variations.

In 1931, Fox developed a group of thio-carbamides, of which phenyl-thio-carbamide may be taken as a type. This substance tastes bitter to most people but tasteless or even sweet, salt or sour to a certain proportion. Blakeslee and Salmon, and also Snyder, have shown that failure to taste phenyl-thio-carbamide as bitter is inherited as a Mendelian recessive. Taste blindness may thus be applied to racial study. This was first done by Levine and Anderson, who added to existing figures for American whites data on pure and mixed Indians at the Haskell Institute. Parr and coworkers greatly extended this racial survey of taste blindness to include Chinese, Negroes, Egyptians, Aschkenasim, Sephardim, Semenites, Armenians and Arabs. The results obtained when set in order show a decreasing acuity of taste for phenyl-thio-carbamide in this order, Chinese, pure Indians, mixed Indians, Negroes, Egyptians, Sephardim, American whites, Aschkenasim, Armenians, Semenites, Arabs.

Other sensory deficiencies should be sought and, if found, applied to racial study, particularly if they can be shown to have fundamental genetic significance. Thus Blakeslee has indicated a variety of odors, chiefly from flowers toward which different workers react differently, and Parr has collected three cases of persons insensitive to the "peculiar, penetrating, quite characteristic odor, resembling that of peach kernels" of hydrocyanic acid, a poison of considerable medico-legal and industrial significance. Cook has pointed out that a knowledge of these sensory peculiarities makes one more tolerant. Spinach may actually taste as badly to some children as they pretend, and that "finicky" husband who at the table is the despair of his wife may not be merely stubborn after all.

The question of racial odors is one which has as yet received but little scientific attention, although numerous allusions to the subject have existed in general literature for hundreds of years. These allusions are commented upon and the question of the odors exhaled from the skin discussed by Günther. As he makes clear, there are two sorts of odors to be considered. First are those inherent in the race and secondly are odors acquired in a variety of ways, too often dependent upon careless hygiene, squalid conditions of living, articles of diet or even disease. Unfortunately, both sorts have been confused in the past and the odium cast on body odor because of its common association with poor hygiene has so obscured the point that possibly existing true racial odors are overlooked. The point is further complicated by the probability that each race, inured to its own odor and ignorant of it, may apparently be conscious of an odor in other people chiefly because their own odor is absent. However valuable the determination of true racial odor may be, its detection, chiefly subjective, will always be most difficult and because of the odium attached to the matter not an easy study to conduct.

We may lastly consider the applica-

RESULTS OF TASTE BLINDNESS TESTS MADE ON DIFFERENT RACE GROUPS

Group	Worker	Place	Total number tested	Per cent. of bitter tasters
Chinese	Chen Chain	Washington New York	167	94.01
Pure American Indians	Levine and Anderson	Kansas	183	93.9
Mixed American Indians	Levine and Anderson	Kansas	110	87.2
Negroes	Howard Campbell	Alabama Georgia	533	76.5
Egyptians	Hickman and Morcos	Egypt	208	75.9
Sephardim or Southern Jews	Yunovitch	Palestine	175	72.0
American Whites	Snyder	Ohio State U.	3,643	70.2
American Whites	Parr	Washington	439	69.1
Aschkenasim or Northern Jews	Yunovitch	Palestine	245	68.5
Armenians	Berberian	Syria	294	68.02
Semenites	Yunovitch	Palestine	59	67.7
Arabs	Hudson and Peter	Interior Syria	400	63.5

tion of isohemagglutination to racial study. This aspect of immunology deals with blood groups which have been recently discussed in these pages by Lambert and voluminously elsewhere by various writers. The four established groups, O, A, B and AB are becoming increasingly well known because of their determination in selecting donors for blood transfusion and because of their growing use in medico-legal work. The specially demonstrated groups M and N of Landsteiner and Levine, though less well known and much more difficult to demonstrate, have already been found most helpful in expanding the usefulness of the ordinarily determined four types in legal medicine and may well likewise contribute to anthropology. The blood types are fixed biochemical entities not subject to change when once formed in the child. They are formed according to definitely known hereditary laws, and O, A, B and AB may be determined by rather simple technique. Thousands of blood-typing tests have been carried out the world over and, since the pioneer application of blood-type determinations to racial study by L. and H. Hirszfeld in 1918 and in 1919, a great deal of material on serological anthropology has accumulated. Various values are computed from the percentage distribution of the four types in a given folk group from which tables and charts are constructed of value in racial study. Hirszfeld's "biochemical race index" is the ratio of A to B. The values p, q and r express the frequencies A, B and O, as determined from formulae readily available to the student. We shall conclude our discussion with mention of a few

Q \ P		I	II	III	IV	V	VI	VII	VIII	IX	X
		0–0.5	0.6–1.0	1.1–1.5	1.6–2.0	2.1–2.5	2.6–3.0	3.1–3.5	3.6–4.0	4.1–4.5	>4.5
A	0–0.5	American Indians	American Indians Polar Eskimos	American Indians	Australians	Belgians Greenlanders Australians	Lapps in Sweden English Maltans		Hawaiians	Lapps in Sweden	American Indians
B	0.6–1.0		Filipinos		Negritos Brazilians Melanesians Icelanders	Samaritans Italians Danish Americans	Christian Arabs French Germans Austrians Bulgars Americans German Jews Serbs Greeks Dutch Swiss	Lapps in Sweden Swedes Norwegians Italians Armenians			
C	1.1–1.5			Igorotes Yorubas Natives of South Africa Moroccans	Madagascans American Negro English Jamaicans	Aschkenazim Jews Aleppo Jews Arabs of North Africa Turks Russians Spanish Jews Americans Slovaks	Moslem Syrian Arabs Armenians Ainus Tcheques Finns Germans Roumanians Korean Japs Polish Jews	Armenians Assyrians Bulgarians	Armenians		
D	1.6–2.0		Bogobos	Sulu Moros Senegalese Sumatrans	Sephardim Jews Samoans Katangans Annamese Javanese Chinese Sumatran Chinese		Druzes Persians Beirut Jews Chinese Japanese Poles Hungarians	Roumanian Jews Japanese Formosans	Japanese		
E	2.1–2.5			Ainus Gypsies	Ainus Koreans	Koreans Chinese	Egyptians Koreans	Egyptians Koreans	Ukrainians		
F	2.6–3.0			Natives of India	Chinese Manchus		Ainus Hungarians Koreans Gilyac				
G	3.1–3.5			Samal Moros							
H	3.6–4.0							Ainus			

The values for the distribution of the blood-typing gene factors O, A and B may be calculated. A two-dimensional chart for any two of these values can be constructed by which different racial groups are arranged together, showing the serological identities. These identities may be coincidental or they may possess definite anthropological values. Such a chart is reproduced above (modified from Parr.) Note the distribution of Ainus in five different squares and the presence of Samaritans with Italians, Danes and Americans,—unusual result due to inbreeding. Note also how new work on American Indians by Matson and Schrader makes necessary a new square, A–X.

only of the many contributions made by blood-typing to anthropology.

Studies on pure American Indians prior to 1933 have indicated that they fall into blood group O. Relatively high concentrations of A exist in northwest Europe and of B in the Hunan areas of eastern Asia. An attractive hypothesis has been that America separated off from Europe and Asia before mutations of A and B occurred. Present-day blood studies on folk groups no longer pure O, A or B should indicate something of the racial relationship and migrations of the past. In 1933, however, Matson and Schrader reported results on heretofore untyped Indian tribes demonstrating a high value for the gene A. Apparently then there was a mutation of A in America as well as in Europe.

Grove's study of the Ainus was a most important contribution, for it put a stop to indiscriminate accumulation of blood-typing racial data. She found that the Ainus, essentially one people, were when tested on their several islands of different blood-typing racial formulae. Parr studied the surviving Samaritans in Nablus, Palestine, with the idea that the inbreeding presumably operative in this small group of people would give them a blood picture entirely unwarranted by their known anthropological features and history. This was found to be the case and justifies the explanation that Grove's anomalous results with the isolated Ainu groups might be explained on a similar basis. It is now believed that given due consideration to technique any blood-typing survey of a considerable number of members of a folk group not unduly interrelated will contribute information of anthropological value.

In 1925 Parr was able to state from blood-typing studies that the Arabic-speaking peoples of old Syria fall into two distinct groups. One of these, the Lebanese, are identified by blood typing as closely related to the Khaldeans and Armenians, and these three groups, according to Kappers, appear from anthropometric studies to be related to the Hittites. The Arab group in Syria, the Adnan Arabs, Parr identified by blood-typing as related to the North African Arabs tested by L. and H. Hirszfeld. Blood-typing tests done by Shousha and by Parr confirm other observations that the Egyptians are dissimilar to the Arabs of North Africa or Western Asia. Parr's results with Persian students at Beirut indicate that they have the same blood picture as the Adnan Arabs. Jews typed the world over present such dissimilar blood pictures we must conclude that although Aschkenasim and Sephardim may once have fairly described two great divisions of this people it is more accurate now to speak of the Jews as a religion than as a race. On the other hand blood-typing tests show that the Gypsy has retained his original racial identity, although he has been centuries separated from his original home.

SOCIAL LIFE OF THE BARAMA RIVER CARIBS OF BRITISH GUIANA

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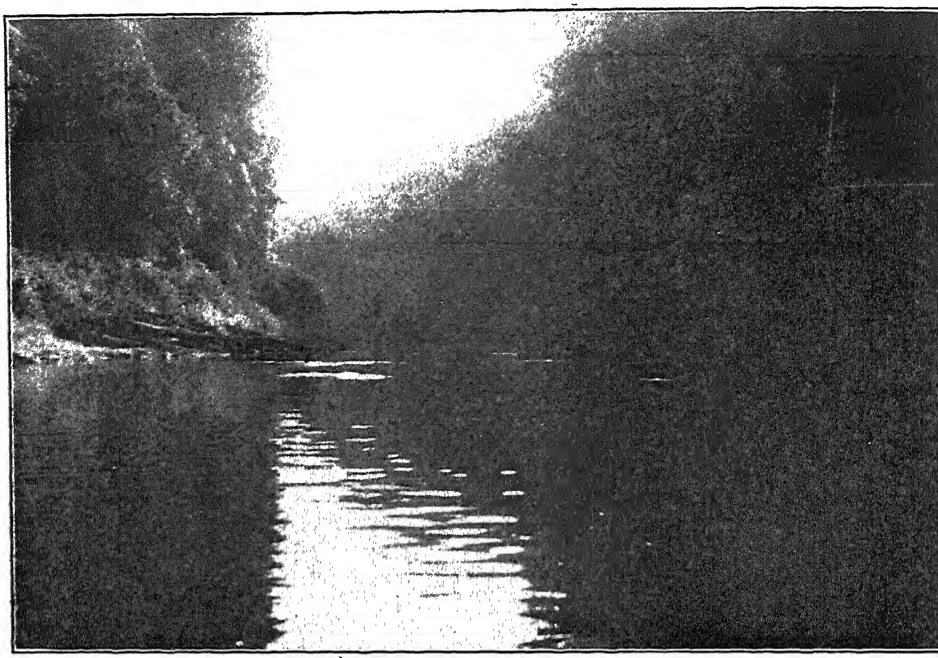
THE Caribs have lent their name to one of our more picturesque seas, the Caribbean, and, it is said, to the enrichment of our language with the word "cannibal." Accounts of their ruthless methods of warfare and clever navigation of seagoing canoes have on occasion adorned the literature of adventure. But they have long since relinquished their anthropophagous habits and left the scenes of their conquests in the Caribbean, leaving only a handful of half-breeds on a reservation in Dominica, a settlement of so-called Black Caribs in British Honduras, and scattered archeological remains to recall the period of their domination in the islands. At the present time several tribes of Carib stock, speaking their own respective Carib languages, still inhabit the forests and the savannahs of the Guianas, Venezuela and Northern Brazil.

The history of the Caribs is still largely a matter of conjecture. When Columbus appeared on the scene in 1492 a part of the stock had practically completed the subjugation of the West Indies. Carib adventurers had probably reached the east coast of Mexico and Central America in earlier times. And there is evidence of a general slow migration of Carib peoples northward from the Amazon valley into the Guianas and Venezuela. But the clear outlines of these movements are unfortunately lacking.

The Carib Indians now living within the drainage of the Barama River in the Northwest District of British Guiana, who were the objects of the writer's investigation in 1932–33, number between five and six hundred souls, distributed among some thirty-three villages or settlements. The country in which they live is entirely covered with fairly high jungle and is relatively free from penetration by outsiders. The Indians speak a language which in the colony is known as "Pure Carib" to distinguish it from the other Carib languages in British Guiana. The Barama Caribs call themselves *karinye,* meaning "men." They depend upon hunting, fishing and slash-and-burn agriculture for their livelihood. Bows and arrows of several types are their only weapons, and loin cloths are for the most part their only costume. They live in houses thatched with palm leaves but without walls, sleep in hammocks woven of native cotton or tree fiber and, having no domesticated animals, with the exception of dogs and chickens, depend upon canoe travel on the rivers or walking on the trails for transportation.

We are perhaps too often inclined to think of the social life of people whose culture is thus of a "low" sort as perhaps non-existent, or perhaps as approximating that of lower animals. I therefore propose to present here a short and necessarily incomplete picture of the social life of these forest dwellers, in order to show that, while "primitive," it is perhaps not as simple as it may appear at first glance.

It is an axiom of sociology, based upon practically universal experience of investigators, that all societies tend to group the individuals who comprise them more or less roughly according to the individuals' respective social abilities. Nowhere are individuals created



BRITISH GUIANA JUNGLE

THE RIVER AT PLACES IS FULL OF DEAD TREES WHICH MUST BE CHOPPED AWAY IN ORDER TO GET A BOAT THROUGH.

free and equal in the social sense, and because of the circumstances of their physical heredity and social inheritance they vary as to their capabilities for participation in the life of the society of which they are members. Now in Carib society the groups through which individuals play their social rôles have certain resemblances to groups with which we are familiar, but on the whole the principles of grouping are somewhat foreign to our way of thinking.

The following types of grouping characterize the society of these people at the present time: (1) the family or household; (2) the kin; (3) the extended family; (4) the friendship group; (5) the settlement; (6) the kanaima cult. Sex and age also play a part, in that, outside of the immediate family, the members of the same sex and generation tend to be closer to each other than other individuals in the same group.

It need hardly be mentioned that the groups in Carib society are few in number and relatively indistinct in outline, as compared with those found in many more "advanced" cultures, and for this reason they have rarely been recognized by outside observers.

The family or household group is composed of a man and his one or more wives and their unmarried children. Each family has its own house and it practically never occurs that adult individuals other than the spouses and their children are included in the household group. Other relatives or friends who wish to be near the family have their own houses in the vicinity. There are no individuals above the age of about twenty who are not married or who do not have definite plans to be married, and we may therefore say that every individual in the community belongs to a family. However, it is obvious that in every society an individual may belong

to one or both of two kinds of family, namely, a family of orientation and a family of procreation. Now in Carib society, as among ourselves, it is practically the universal rule that one joins his family of orientation by being born into it. But the formation of a family of procreation, which involves marriage, follows a somewhat different pattern than among ourselves. For a young Carib of either sex, puberty is the introduction to several years of sexual experimentation, during which the young man visits and sleeps with as many marriageable girls as his fancy and strength will permit. Pregnancies rarely result from these affairs, perhaps because of the use of several native contraceptive and abortive methods. Eventually the young man chooses a girl with whom he desires to "settle down" and asks her father for her. The old man requires the suitor to clear and plant a field and to build a house in the settlement of the future father-in-law. These are feats which require several months, during which period the suitor occupies the house of his fiancée's father and enjoys the favors of the girl while contributing his hunting spoils to the family larder. In this manner not only is the constancy of the young man tested, but his ability as a provider is proved to the satisfaction of the girl's family. When these tests have been passed, the young couple move into their new home and take up the course of married life. No religious ceremony solemnizes the marriage. Thus is a family of procreation established. The young married couple live in the settlement of the girl's family until the birth of the first child, after which they may establish their residence elsewhere. Subsequent wives acquired during or after the lifetime of the first wife are taken with the permission of

CARIB INDIAN HOME AND CLEARING
IT IS WASH-DAY IN THIS SETTLEMENT.

CARIB INDIAN HOME

BUILT IN CLEARED SPACE IN JUNGLE. FIREWOOD AND TEXTILES PROVIDED BY OWNER.

their fathers, but without the house and field building tests which are required for a first marriage.

Within the household there exists no formal distinction between the children of polygynous and subsequent marriages, and a child's position in the family depends largely upon its personality and age. The same is true of wives in polygynous families.

The position one occupies in the household group or family depends upon whether the group represents one's family of orientation or one's family of procreation. If one is a child he is subordinate to both of his parents. If one is a married woman she is subordinate to her husband. If one is a married man he is superior to all in the household.

The household group is the primary educational institution of Carib life; boys are trained in the duties of men by their fathers and girls are trained in the duties of women by their mothers. In the absence of club houses or other extra-curricular educational institutions the home is the agency for the dissemination and formation of the socially accepted attitudes. The home is also the primary economic unit of the community, and in economic activities there is a fairly rigid division of labor. Men do the hunting, fishing, house-building, making of basketry, field-cutting, weapon-making and some of the planting. Women do the housework, field work, care for the small children, and make the pottery, raiment and hammocks. All economic goods which have been modified by human hands have an individual owner who can alienate them on contract. Every article about the house belongs to some one in particular. No religious or political functions are performed by the household group.

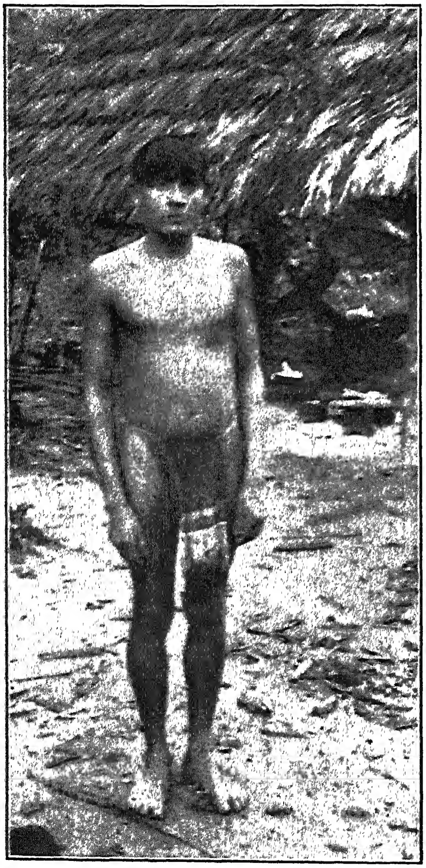
Outside the more intimate relations of the household group lies the larger group of the kin, only the general outlines of which can be sketched here. In the broad sense the kin may be said to include all those individuals to whom the individual in question can trace a relationship which is designated in the terminology. This includes five generations only. The general group of relatives thus defined is regrouped according to certain principles of the classificatory relationship terminology in use. The general characteristic of a classificatory relationship terminology rests in the fact that any given relationship term may apply to a whole class of individual relatives, whereas a strictly descriptive type of terminology uses a single term for each individual relative. Thus mother, in our system, can in the sense of relationship be applied to only one individual among the speaker's relatives, whereas a Carib in speaking of his female parent uses a term which also means "mother's sister," "mother's mother's sister's daughter," and, in fact, all the female relatives of his mother's generation who are related to him through the female side of his mother's family. In speaking of his father he uses a term which means not only "father," but also father's brother and all male relatives of his father's generation through the male side of his father's family. Now these relatives who are related to him through the female side of his mother's family or through the male side of his father's family comprise a group which is known to anthropologists as the "parallel relatives"; the members of his own generation who are thus related to him he calls "brothers and sisters," although the individuals thus addressed outside of the immediate family we would call cousins. This group of parallel relatives forms a group into which one may not marry. Although a Carib is perfectly aware of the members of his own immediate family as such, in the kinship terminology he makes no distinction between these and the parallel relatives whom he considers to be brothers and sisters, fathers and mothers and children, according to the generation in which they stand in relation to himself. However, there still remain a large number of relatives who do not come into this category, for instance, mother's brother and father's sister. Thus all the relatives which are related to him through the male side of his mother's family and those related to him through the female side of his father's family, a Carib calls by a different set of terms, distinguishing them from the parallel relatives. This group we may call the "cross relatives," referring not to their disposition, but to their status in the relationship system. A Carib can always tell you which individuals are actually related to him, but for practical purposes, the terms which are used for the members of the cross relative group are also usually applied to all strangers who are not known to be members of the parallel group. This usage is primarily connected with the belief that the use of the personal name endangers the owner of the name through its possible magical misuse.

It is therefore clear that a Carib is brought up to consider one portion of his kin, namely, the parallel relatives, as closer to him than the other portion, the cross relatives who are terminologically undistinguished from other persons. It is interesting to note in passing that this division of the kin is not connected with an organization. No institution of this kind exists among the Caribs at the present time, nor is there historical evidence pointing to its former existence. The Barama Carib type of kinship organization is quite typical of that found among all the other Carib tribes concerning which we have information. The actual kinship usages among the Caribs support the view that, in the

absence of sib organization, the terminology is closely connected with the customs of the levirate and the sororate which are actively functioning at the present time and seem to have been from time immemorial. Polygamous marriages are frequently with the sister of the first wife. Likewise a widow always marries the brother of her deceased husband. The distinction between parallel and cross cousins becomes clearer when seen in the light of these customs. In many cases marriage with the child of father's brother or mother's sister in such society would mean marriage with an actual half-sister or half-brother.

THE PROFILE OF A YOUNG CARIB INDIAN WOMAN

THE DRESS IS SUSTAINED ALWAYS BY ONE SHOULDER STRAP.



A YOUNG MAN IN NATIVE DRESS

THE LOIN CLOTH IS WOVEN FROM NATIVE COTTON AND COLORED WITH NATIVE DYES.

Such incestuous marriages, with very few exceptions, are prohibited in all human societies.

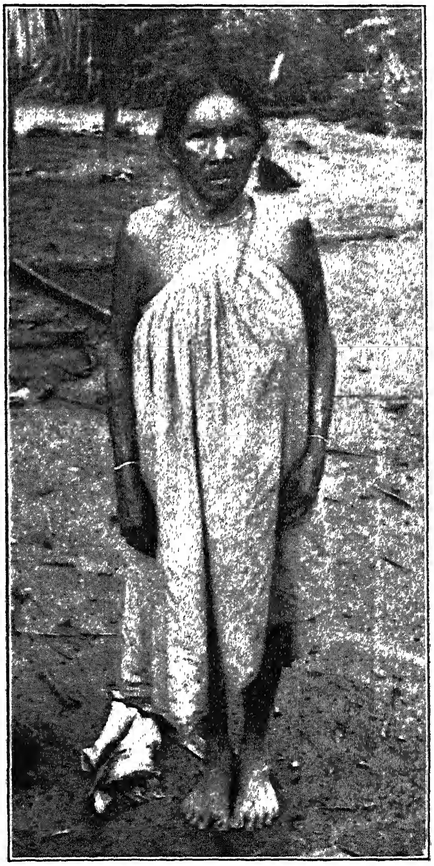
The persons a man includes among his parallel relatives remain in a special relationship to him throughout his life. "Brothers" tend to group together to form a settlement and assist one another in the social and economic affairs of the settlement. They support one another in feuds and retaliations. In all activities the members of the group of parallel relatives cooperate more closely than do other relatives. Membership in the group begins at birth and continues for life. Due to the customs regulating residence after marriage there is, however, no necesssary connection between locality and the kin.

A third type of grouping is the extended family, the immediate family which is, in other words, extended by the marriage of its members. When a

A YOUNG CARIB INDIAN WOMAN
DRESSES ARE WORN ONLY WHEN STRANGERS ARE ABOUT OR ON GALA OCCASIONS.

girl marries, her husband becomes for a time at least intimately associated with her family, because of the custom requiring the husband to perform services before marriage under the eye of his future father-in-law and after marriage to live in the father-in-law's settlement at least until the birth of the first child. Thus a family upon the marriage of its daughters from one point of view undergoes a special transformation consequent upon the addition of strangers in the persons of sons-in-law. The latter, however, do not take the place of the sons who through marriage have joined other extended families. The husbands of the daughters are not taken into the family, which still maintains its biological limits and individuality, as shown by the fact that a special relationship of deference, not formalized into a strict "parent-in-law tabu," but resembling it, exists between the young men and their wives' parents. During the period that marriage remains matrilocal the sons-in-law cooperate actively with the fathers-in-law and with other members of the latter's family who still remain at home. Later opportunity or preference usually impels the young couple to move elsewhere, but a bond still remains between the husband and his wife's kindred which is reflected in mutual cooperation. This bond is, however, slighter than that uniting a man and his parallel kin. With the death of the wife or of the father-in-law mutual obligations are considered ended.

The political unit of Carib society is the settlement, and its basic principle is the common locality of its members. Settlements vary among themselves in



CARIB INDIAN WOMAN
SHOWING USUAL SHAPE OF DRESS MADE FROM TRADER CLOTH.

MOTHER AND CHILD
NOTICE METHOD OF DRESSING THE HAIR.

size from 15 to 70 individuals. Factors which determine membership in this group are kinship, friendship, marriage and accident of birth. Termination of membership is by individual choice, sentiment of the community antagonistic to the individual in question, death and economic factors, such as the exhaustion of the soil and of the hunting grounds. Each settlement is presided over by a headman whose authority is decidedly limited and dependent upon his personality or physical strength. He is usually chosen by acclaim for life or for the existence of the settlement by the adult men of the group. Community affairs are decided informally in conversation among the adult men when they are together during drinking sprees.

CARIB INDIAN MAN
PROFILE OF PHYSICAL TYPE.

Friendship is a strong factor in the social life of both men and women. Regardless of home, kinship or settlement individuals are often especially intimate with other individuals for no other reason than personal congeniality. For practical purposes this form of grouping often lies within the settlement, although I know of cases of men making rather extended tours to visit distant friends. There are always groups of men friends who go hunting together, who build canoes together, tell jokes together, and so on. The same sort of thing is true among women, who, however, due to modified matrilocal marriage, tend to choose their friends among their relatives to a greater extent than do men. In the matter of lending, assistance in work and sociability, friendship plays at least as large a functional part as does mere kinship, which, when it stands alone, implies for the most part, as among ourselves, rights and duties frequently less vital than those of friendship. The difference, of course, lies in the fact that friendships may be terminated when for any cause the congeniality essential to them disappears, whereas kinship ties exist in a stronger or weaker condition for life.

The last type of grouping in Carib society to be considered here is the secret kanaima cult, membership in which is confined to men. Kanaimas are hated outcasts who have voluntarily deserted respectable society to roam about the deep jungle perpetrating outrages on individuals unfortunate enough to come in contact with them. It is difficult to obtain precise information concerning

them, because no native will admit having been a member of the cult. But the evidence seems to show that such an organization actually exists, although many of the activities attributed to it are doubtless the products of terrified imaginations. Men who have misogynistic temperaments as well as those who have been unable to obtain redress for an offense against themselves in any other way are said to compose the recruits. Once they have taken up the life of the kanaima, they must leave family, tongues of their victims so that the latter are unable to give information concerning what has befallen them, and after the victim has been buried the kanaimas, to complete their task, must reach the corpse and drink the liquids of decay from it. From the social point of view the membership of the cult, if such actually exists, represents an important, though perhaps temporary, division of the population, a group which is, however, outside the limits of normal society.

CARIB INDIAN WOMAN

THE HAIR IS OFTEN BRAIDED AND SOMETIMES COILED ON THE BACK OF THE HEAD.

kin and friends, and forsake all the advantages of the native culture. They are taught to live a life of extreme hardship without shelter or the ordinary foods and, in the process of training, are said to learn the magical procedures whereby they can overtake an unsuspecting individual in the bush, anesthetize him, twist his joints while he is unconscious, and send him home with fever, where he dies within a short time. It is believed that kanaimas pierce the

Six types of grouping have been described, the entire range of social groups in Barama society at the present time. The first five types, immediate family or household, kin, extended family, friendship group and settlement, may be considered basic features of the social structure. The kanaima cult is a specialized grouping not directly connected with the social organization of the community as a whole.

Sex and age, factors which are pres-

ent in all societies, further affect the social life of the Carib community. Here, as elsewhere among human societies, are infants, adolescents, middle-aged adults and old people. Here also are males and females. However, no groupings in Carib life depend primarily upon either of these factors.

The only specialists in Carib society are headmen, priests and sorcerers, and it may be asked why these are not assigned to special groups. Although each of these officials is distinguished from the commonalty on account of his position, each is a lone wolf in his official capacity, requiring in his official functions the assistance of no organized group of colleagues. Furthermore, each settlement has only one headman and usually only one priest and one sorcerer, never more than three, so that a local basis for grouping is absent. In the frame of Carib society as a whole these three officials may be said to belong respectively to three professional classes, but these classes are not in any sense functioning groups because the members, although fulfilling similar individual functions, do not cooperate in these functions.

The Carib cultural adaptation to the jungle environment, depending upon a wide hunting territory and small fields which must be frequently abandoned for lack of fertilization, necessitates small and isolated communities and promotes individualism in economic activities, tendencies which are not conducive to highly organized social life.

Enough has perhaps been said here to indicate the simplicity and lack of formalism of the Carib social structure. The Carib society is essentially a collection of small hordes, organized into four or five other types of groups, but without formal stratification, depending upon age, wealth, social position or any other factor. Those familiar with Australia will at once recognize the contrast between this sibless society and the elaborate clans, totems groups, marriage classes, sections, sub-sections, cycles, pairs and other subdivisions of the central and some of the northern tribes of the continent. The Carib is not obsessed with kinship terminology, as many of the Australians seem to be. Here we find none of the elaborate social stratification of, for instance, the American Northwest Coast or of Polynesia. Here also is nothing of the centralized governmental control inherent in the social system of the Incas or of the West African kingdoms. Nor does the kinship group of the Caribs possess either the economic functions that it does, for instance, among the Ifugao of Luzon or the Kazaks of Central Asia or the political functions of the Iroquois clan. It seems to be one of the simplest social systems of which we know in the jungle portion of South America, for the Arawaks are known to have matrilineal localized clans, the Witoto and Boro have patrilineal gentes, etc. Much remains to be learned concerning the social life of the forest tribes of South America, and when this information is available the place of the Caribs on the scale of complexity will be better known. But with all its simplicity, as we have seen, Carib society organizes its members into groups, as do all societies, for greater efficiency, and the individual's social life is far removed from that of the lower animals.

HOUSE AND VILLAGE TYPES OF THE SOUTHWEST AS CONDITIONED BY ARIDITY

By J. W. HOOVER
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THE sub-tropical hot desert type of climate of the lower Colorado River drainage basin and the upper valley of the Rio Grande with their bordering steppes constitute a region of distinct character as contrasted with other parts of the United States. Here, then, we may look for distinctive human adjustments to climatic conditions resulting in peculiar or indigenous forms. Most universal and conspicuous of cultural forms are house and village or community building types. Yet often in the more highly developed districts of the arid Southwest one fails to be impressed with anything distinctive architecturally except a few scattered old houses or neglected old buildings in less frequented locals which have failed to share in the general quickening prior to 1930. Outside of New Mexico, where a conservative Spanish-speaking population of low living standards is considerably in the majority, there has been considerable leveling of structural types due to mobility of population and fluidity of ideas shared with other parts of the country. So local indigenous forms have often been submerged among the exotic styles introduced through a rapid influx of population steeped in the culture of a different clime and uninured to the modes of the desert. Will the desert eventually impress its stamp upon this heterogeneity to produce a fusion in harmonious adjustment?

For that which is more typically desertic, we may look to the simpler indigenous cultures and even to the adjustments of the American pioneer settlers. Indian cultures were supplemented by Spanish or Mexican culture and house types. The first American settlers, isolated from their kind, adopted the forms of those who had preceded them in the land. Later settlers, coming in larger numbers and less completely cut off from old cultural ties, employed their accustomed building methods and materials, but modified their style of building to suit the climate.

CONDITIONING FACTORS

The character of the desert house is determined largely by two sets of natural facts: (1) Conditions imposed by climate; (2) materials available for construction.

The climatic factors which taken together set apart the areas designated as a climatic province in the United States are the same as characterize all the arid regions of the world bordering on the Tropics. They are: (1) *Low rainfall,* generally less than 10 inches, although the limit will vary with temperature and other conditions; as affecting cultural forms, no definite limit can be set. (2) With low rainfall invariably goes *low atmospheric humidity,* which more directly affects human comfort. (3) Also continuous sunshine. (4) Very high summer temperatures. (5) Mild winters with little freezing weather. (6) High diurnal range, commonly over 25 degrees.

The matter of building materials is of paramount importance where the desert community is isolated or the standard of living is low, and diminishes in importance with ease of communication and

greater wealth. The materials of the desert are earth (adobe) or stone, with perhaps sufficient woody growth to supply beams or even upright supports.

Clayey soil makes up for the scarcity of wood in the arid zone. It can be easily molded and will absorb substances which solidify and harden it when dried in the sun or baked in the fire. The clay is also used for cooking utensils and for vessels to contain and to cool liquids, as the well-known *olla* of the Southwest. In Northern Africa and Southwest Asia even clay furniture and earthenware chests are used. If one is looking for beginnings, he will learn that architecture using bricks did not originate in the places where it is developed farthest to-day, but in the arid regions of the world. In districts arid enough for the use of sun-dried brick, clay has always maintained its supremacy. The great Chaldean and Assyrian palaces, even those which succeeded them in western Asia up to the time of Alexander, were built almost exclusively of clay.[1] "The native of such regions is earthy in the most literal sense of the word;—earth in his domicile, whether he builds upon the ground or conceals himself within."

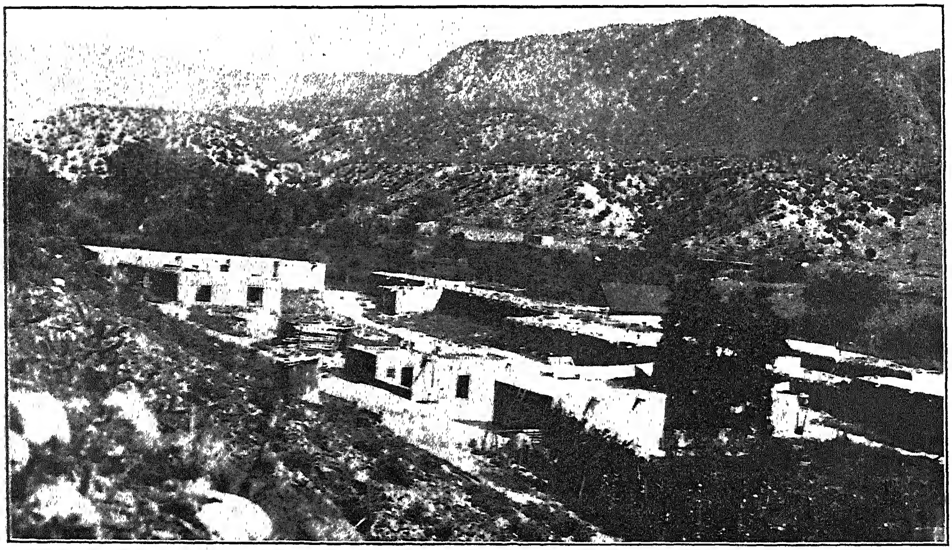
[1] Vidal de la Blache, "Principles of Human Geography." Translated from the French by M. T. Bingham, pp. 240–241. New York, 1926.

The need of protection from nomadic tribes is a social factor which often has played a large part in structural arrangements.

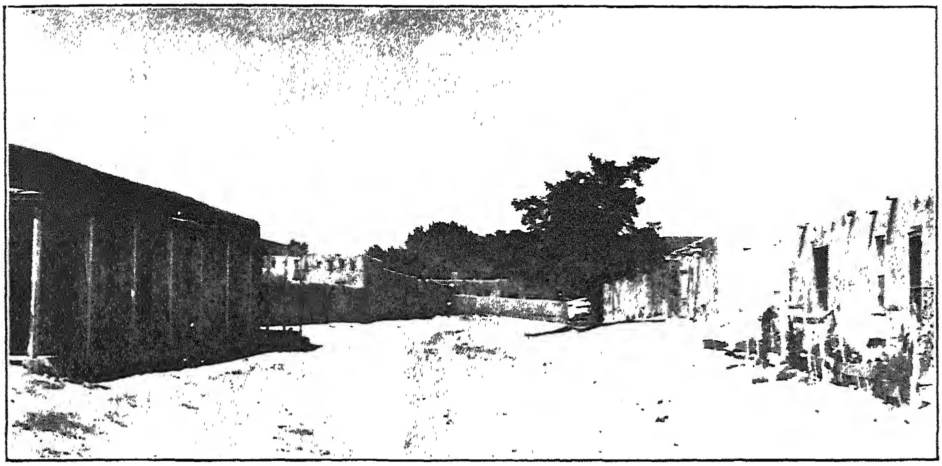
The Typical Desert House Type

In its simple form the mud or adobe block house, characteristic of the Mexican villages, may be taken as the general and well-nigh universal type of arid and semi-arid fixed habitations. Toward it the more primitive house types tend in their evolution. From it as the basic form emerge more elaborate forms of more highly bred cultures of the dry regions.

The adobe house is usually simply rectangular in form, flat-walled and flat-roofed, with little window space. If larger it takes the form of an L, T or U, or it may enclose a court. A space partly enclosed by the house may be completely enclosed by an added adobe wall forming a "patio." Built of the earth on which it stands, the drab buff of walls and roof blend with the same color of the soil. The universality of



TYPICAL MEXICAN OR SPANISH VILLAGE ON UPPER RIO GRANDE, N. M.



STREET IN ALCALDE, N. M.

this as a desert form is evidence of fitness to the environment. The thick adobe walls, roof and floor are effective insolation from the glaring heat of the desert. Deep-set windows in thick walls emit little or no direct sunlight, and from the heat of the desert the cool dim light is inviting. During the heated part of the day doors and windows are closed and the house remains very comfortably cool until lengthening shadows break the glare of the sun and the heat begins to moderate. During the night the temperatures drop from 25 to 35 degrees or even more, and the house is again effectively cooled for the coming day.

It seldom rains; so the pitched roof of rainy or snowy climes is not needed. The roof is commonly built by laying beams or rafters on top of the walls. Across these, poles are laid close together. These, covered with grass or weeds, support in turn a few inches thickness of earth. Such a roof may suffer severe erosion during occasional sporadic downpours characteristic of the desert. Or if there is an unusual rainy period, the roof and even the walls may become soaked, and the house with contents seriously damaged.

In parts of the world where the supply of wood for beams is scant or has been depleted, an inverted basin-like dome or cupola must be resorted to to cover the space between walls. With the disappearance of the supporting wooden framework for the roof goes also that of the runway for dripping rain. Cupola construction, mothered by necessity, is also widely distributed, and represents the highest structural achievement of some groups. It is an especially common form through southwestern Asia and may be witnessed even in the Sahara. In Kurd villages of Turkestan and the villages of the Alepp Plain of Syria, the earthen or brick dome becomes the entire house, a beehive form with the flat walls eliminated.[2]

Instead of being domed, the rectangular rooms are sometimes barrel-vaulted, a form especially common in Egyptian villages and in Mesopotamia. Neither the barrel-vault nor the cupola have entered into the primitive house construction of the Southwest, most likely because of the availability of material for beams large enough for the roofing of small structures. However, the rudiments of such construction are found in

[2] Illustrations, *Nat. Geog. Mag.*, Vol. 54, October, 1928, p. 502, and October, 1930, p. 494.

the sizable ovens of the Papago Indians, the Hopis and the Rio Grande pueblos.

The simplicity of the adobe house is also due in large part to the fact that the climate makes so few demands upon shelter. Most of the life is out of doors. Even the outdoor patio and the roof of the house become important outdoor adjuncts of the house and accommodate a large share of the household activities and diversions. In this respect the native of the Southwest is somewhat like the Egyptian, who does not build for his own use and comfort, but who lives out of doors in the open sunlight the year around, using his house only as a shelter for the night. Nor does he need shelter like the peasant of northern countries for the long gloomy evenings of the winter.[3]

The clay of the desert is rich calcareous material which in nature forms calcareous concretions or the hard stratum of "caliche" beneath the surface. This, dried in the adobe blocks, hardens and binds them. Its natural consistency is reinforced with weeds or stubble mixed with the mud, and it is then put into molds and allowed to harden into blocks of varying sizes; but blocks about 14 inches by 12 inches by 4 inches are the most conveniently handled. In ancient Egypt, when stubble or "straw" became scarce, the enslaved Israelites, with the other brickmakers, had to forage for their own straw, and finally had to make a poor quality of brick without straw.[4]

The adobe itself may be scarce or difficult to obtain, in which case stone-wall construction takes the place of the earthen walls. Where both are available, stone and adobe walls will each be employed, or the same wall will contain large proportions of both materials. In lower Egypt no stone and very little wood is used, hence the mud house; but in upper Egypt, where there is plenty of stone, the houses, though similar in form, are of stone construction.[5]

Primitive inhabitants of the desert, other than oases dwellers, are necessarily nomadic. Their house forms, if such they may be called, seldom go beyond the most primitive forms, as tents or lean-tos, usually covered with the skins of the animals incident to the nomad's pastoral existence. Felt made from hair or wool may also be used, and with commercial contacts, the hides or felt may give way to canvas. In restricted areas in the southwestern states, the small tepee tent of the sheep-herder is the only human shelter to be found even to-day.

Until recently primitive village dwellers of the Southwest were subject to raids from the nomadic Apache Indians, who took refuge in the mountain fastnesses bordering the arid basins. To the

[3] Jean Brunhes, "Human Geography." Translation by I. C. Le Compte, pp. 102–104. New York, 1920.

[4] Genesis, v: 6–19.

[5] Brunhes, *op. cit.*, p. 107.

INDIAN PUEBLO, ISLETTA, N. M.

east were also the Comanches, who followed the wild herds of buffalo which supplied them with the necessities of life. The shelters of these tribes were necessarily of the simplest construction. With the depletion of the buffalo herds the Comanches too became raiders. The Navajos of northern Arizona and New Mexico, at first primitive hunting nomads and later pastoral nomads, similarly harassed the peaceful pueblos on the Rio Grande and those of the Arizona Hopis. In their houses or hogans they have since failed to keep up with their general progress.

"Like house, like village." In Arizona the Mexican villages are seldom more than adjuncts of the American towns; but in New Mexico, they are as distinctively Mexican and as frequent as south of the International Boundary. Low and dull-colored, they squat upon the land, blending with the color of the dry earth, or massed on slight eminences they appear as flat prominences. Except for the arrangement of houses in rows or around courts, they have little plan. Seldom is a house more than one story high. Rising above the general flatness of the village is one conspicuous structure, the church, surmounted by a wooden cross. Yet how common is the type with a few variations in many parts of the world.[6]

[6] Compare description of Egyptian Village—Brunhes, *op. cit.*, p. 122.

Ancient or Prehistoric Construction and Primitive Elements

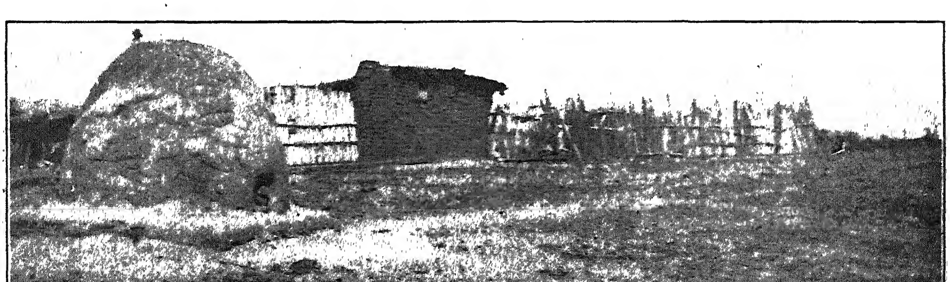
Through central and southwestern Asia and through Egypt, ruins lie upon ruins. For, "if the house is fragile, the village is also ephemeral."[7] Contrasting the durability of earth and stone, "Thucydides, in an oft-quoted passage remarks that if Athens and Sparta were to fall in ruins anyone unfamiliar with their history would be tempted, after a glance at their monuments, to exaggerate the importance of the one and underrate the importance of the other."[8] In the Southwest, too, hundreds of ruins, mostly reduced to mounds, are widely scattered. The more advanced of these prehistoric cultures do not date so far back in Asia and Egypt, but even here the ruins of an older village are often found under those of a later one.[9]

The rectangular forms in house construction have in most cases been preceded by round forms. Earliest types of shelter found in the Southwest, excepting the cavate dwellings, were the pit houses, excavated in flat surfaces and having a superstructure. As the latter developed, the dwelling emerged from the ground and evolved into the earthen-walled house. The culminating prehistoric structures, as seen in the

[7] Brunhes, *op. cit.*, p. 122.

[8] Vidal de la Blache, *op. cit.*, p. 255.

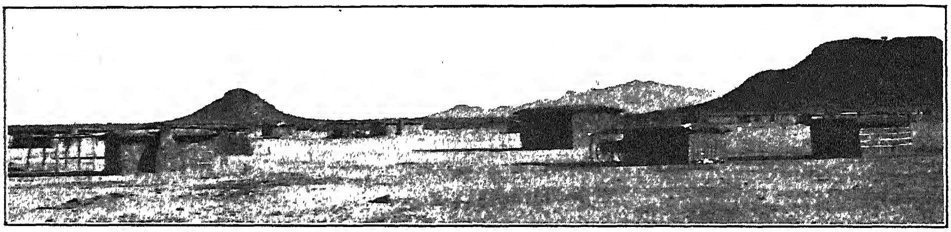
[9] Compare Vidal de la Blache, *op. cit.*, pp. 243–247.



PAPAGO INDIAN BAKE OVEN AND HOUSE BUILT OF ADOBE BLOCKS, VILLAGE OF COBABI, SOUTHERN ARIZONA

"Big House" at Casa Grande Ruin on the Gila River and the splendid masonry compounds of compacted terraced houses, often built in recesses of the cliffs in the Plateau Country, are the climatic expression of the need for protection in a period of beginning decline. The four-story "Big House" at the Casa Grande Ruin is believed to have been a watch tower. Such structures were quantitatively hardly more important in their day than were the masonry temples of ancient Egypt, which then as to-day shadowed the mud hovels of the populace. The one-story house was the rule.[10]

ment were successfully tried.[11] Very likely the walls reinforced by juniper rods were in turn preceded by houses with thinner mud-plastered wattle walls such as those of the Pima and Papago Indians of to-day or were contemporaneous with them. Before leveled for modern irrigation, both the Salt and Gila River plains had a considerable number of mounds, indicating the support of a large population. A few of the larger still remain. In the Salt River alone there were 240 miles of acequias, which may have watered over one hundred thousand acres of land, though not likely all at the same time.[12]



KUKOMALIK, PAPAGO INDIAN VILLAGE OF SOUTHERN ARIZONA

The builders of Casa Grande had not learned to make adobe blocks. The walls were piled up without the use of forms. Caliche was puddled with water to make a stiff mud, carried in baskets and piled along in courses and patted into shape. When dry it was ready for the next course. In a preceding stage, as found in one of the oldest compounds, the walls were reinforced with rods of juniper which must have been floated down the Gila or carried many miles from the mountains to the east. These core rods were bound together with arrow-weed switched and plastered with about four inches of caliche mud on either side. No doubt, as the juniper became more scarce or more distant, walls without reinforce-

Primitive Antecedents Illustrated in the Construction of South-western Indians

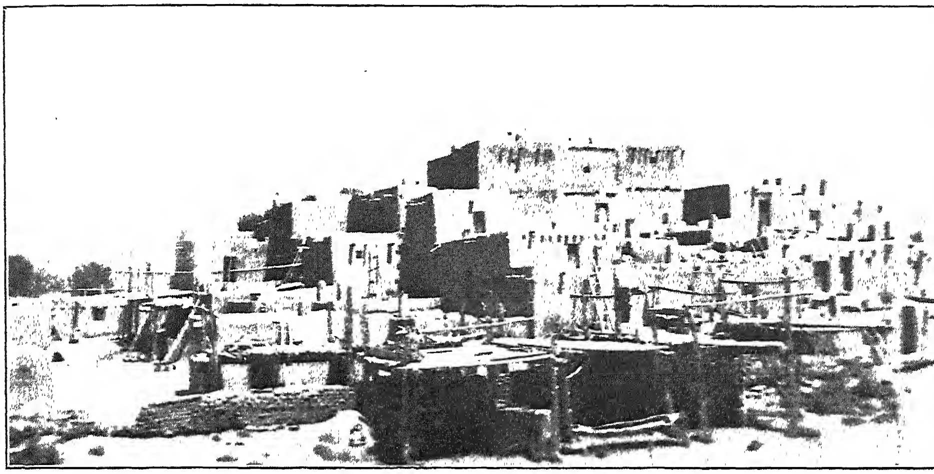
The houses of the present-day Indians of the lower Colorado Basin are further suggestive of the primitive types which antecede the typical adobe house. These forms and the changes are common to all the southwestern tribes, *viz.*, the Pimas and the Maricopas on the Gila and Salt Rivers, the Papagos in the desert south and the Mojaves and Yumas on the Colorado River.

The most common modern Papago or Pima house is a one- or two-roomed flat

[10] H. R. Patrick, "The Ancient Canal Systems and Pueblos of the Salt River Valley, Arizona," Phoenix, 1903; O. A. Turney, *Arizona Historical Review*, Vol. 2: 45–46, April, 1929.

[11] Edna Townsley Pinkley, "Casa Grande, the Greatest Valley Pueblo of Arizona," pp. 9–13, Arizona Archaeological Historical Society, 1926. See also J. W. Fewkes, "Casa Grande, Arizona," 28th Annual Report of the Bureau of Ethnology, 1906–07, pp. 33–179.

[12] O. A. Turney, "The Land of the Stone Hoe," p. 5, Phoenix, 1924.

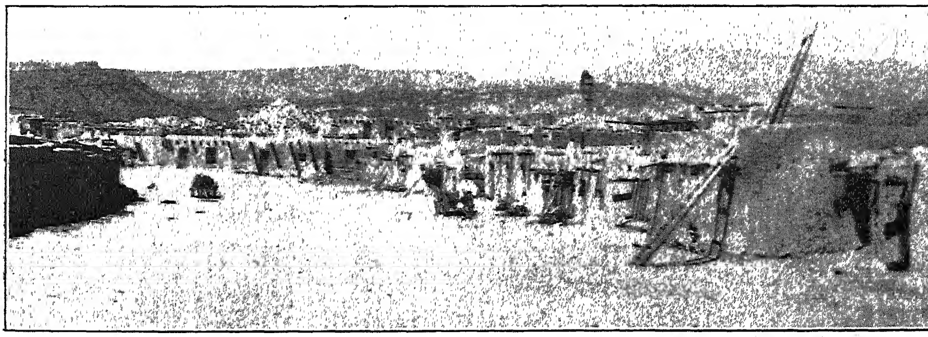


ONE OF THE TWO GREAT HOUSES AT TAOS INDIAN PUEBLO, N. M.

earth-roofed hut built of adobe blocks. It differs from the common Mexican type of adobe house in that the roof extends over the walls instead of the walls extending above the roof. The walls, built wider at the top, curve outward, so that the rain-water will drip off instead of following the wall, and the house may appear as if its walls are falling out. Most Pima houses have stoves, but most Papago houses depend upon a fireplace and chimney built on to the house. Side by side with this type of house is the old and more primitive wattle or mud-and-stick house. Strangely, the Pimas, who have the more fertile well-watered lands and are in more immediate contact with the white civilization, adhere in larger proportions to the more primitive type of dwelling than the Papagos.

Just across the Mexican boundary, on the southern fringe of the Papaguerio, the Indians are isolated, poor and backward. Here the wattle house is the rule, but no poorer than those of their Mexican neighbors, whose homes are identical in construction.

The wattle house is supported by four or more crotched cottonwood posts over which are laid cottonwood or mesquite beams. For the side walls, poles are fastened to the supports, inside and out about two feet apart. To these horizontal ribs are then fastened vertically a wall of arrow-weeds, or ribs of the sahuaro, or giant cactus (*Carnegiea gigantea*).



STREET IN JEMEZ INDIAN PUEBLO, N. M.

and the whole is plastered with adobe on both sides. A number of cottonwood beams laid over the top support the roof. Poles are laid across these at right angles, and over the poles a covering of arrow-weed. A covering of about a foot of mud finishes the roof. Arrow-weed and cottonwood grow only on the river flats, so the Papagos of the desert use ocatilla stems or sahuaro ribs in place of arrow-weed stems, and mesquite, paloverde or ironwood instead of cottonwood. When new, the wattle house presents a fairly finished appearance, but the outer adobe soon crumbles off if not renewed. Some of the wealthiest Indians on the Pima Reservation continue to live in such houses, so adherence to them can not be laid entirely to poverty.

Near the house there is often a storehouse for grain, perhaps without the mud plastering, and an arbor or ramada, with the roof like that of the house supported on crotched posts. Near about the Pima house or cluster of houses is a well with a pail on a rope over a pulley, as along the Gila or Salt River the water table is near the surface. The Papago village is fortunate if it has one dependable well or spring. Near the village is the ubiquitous corral, constructed of brush or staked poles.

Originally the Pima homestead consisted of a primitive hut resembling an overturned wash basin, together with an outdoor kitchen and ramada for shade. The round hut or "kih" have only recently been entirely abandoned, except for several in Papago villages, where they are now used for storage. The roof of the kih was supported by a framework like that of the present wattle house. Around this a circle of light willow poles was set in the ground and bent over on the support with their tops bound together and the whole covered with the earth. The kih was from ten to twenty-five feet in diameter and only about five feet high inside. Erect posture was not possible, and the doors were so small that they had to be entered on hands and knees. There was no smoke hole, so the room was grimy and smoky.[13] While bearing no resemblance to the wattle house, their construction had so much in common to it that the step from one to the other was very easily made. The new type was suggested under Spanish or Mexican influence. The outdoor kitchen persisted until chimneys or stoves were introduced and is still employed in isolated

DETAILS OF PUEBLO ARCHITECTURE, JEMEZ, N. M.

[13] Farish quotes James E. Rusling, Vol. 6, pp. 9–11.

REMAINS OF CAVATE DWELLINGS IN VOLCANIC TUFF CLIFF, PUYÉ, N. M.

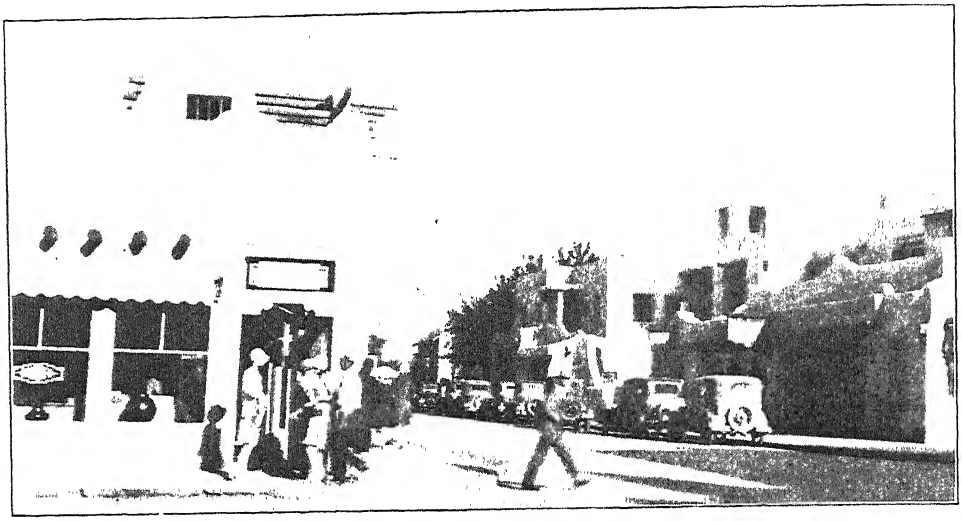
villages. The ramada persists and is often an adjunct to the hut.

Protective Adaptations

During the period of most extensive Apache vandalism, prior to 1878, Pima and Apache villages became more concentrated; with greater security the larger villages tended to break up. The Papagos fortified several suitably situated elevations, but never was their manner of building directed to this end, as was that of the builders of the terraced piles of prehistoric and modern pueblo of the Southwest.

On the southern margin of the Papago Country in northern Sonora may be seen numerous short rock-walled platforms or trencherias located on detached hills or mounds suitable for defense or lookouts. At a distance these terraced rows of houses must have

THE CLIFF PALACE RUIN, MESA VERDE NATIONAL PARK



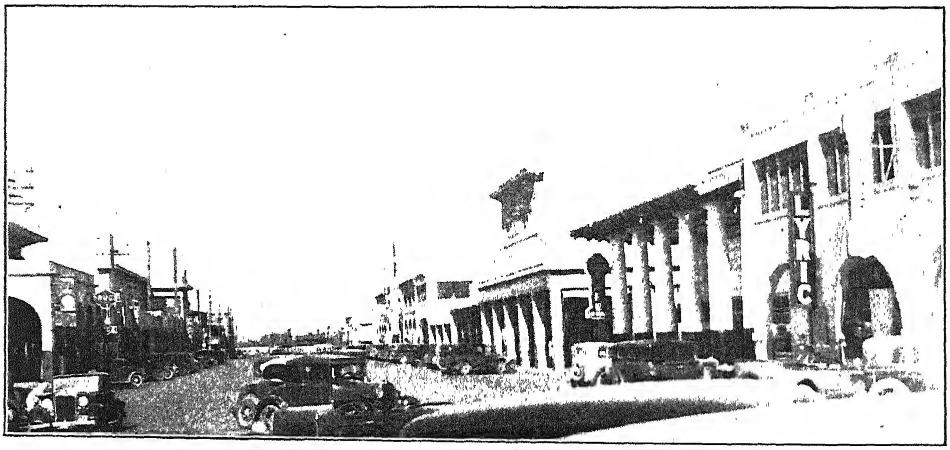
ADAPTATION OF PUEBLO ARCHITECTURE IN MODERN BUILDINGS, SANTA FE

crudely resembled some present-day Saharan villages. Sauer believes them to have been places of residence for agricultural communities situated and built with a view to greater security.[14] Like their probable contemporaries in Arizona these people also reared fortified compounds in the lowlands and surrounded them with walls,[15] but only in their later history as they came under the threat of nomadic raiders.

In the highlands to the north, the village became a single unit, culminating in the terraced pueblo, which in the times of greatest danger was built on mesa summits or in an inaccessible recess in the cliffs. The terraced pueblo is at its best to-day in Taos, New Mexico, with its two great four- or five-story houses. It is still characteristic of the

[14] Carl Sauer and Donald Brand, Univ. of Colorado Publications in Geography, Vol. 5, No. 3, pp. 67–148. Ref. pp. 67–79 and 114.

[15] Sauer and Brand, *op. cit.*, p. 74.



THE MAIN STREET OF YUMA, ARIZONA, SHOWING SIDEWALKS PROTECTED FROM DIRECT SUNLIGHT

Acoma Pueblo, New Mexico, and the Hopi pueblos of Arizona. But most of the Indian pueblos have flattened out with the advent of peaceful security.

The prehistoric cliff dwellers in the Southwest, as in other parts of the world, were often partly cavate dwellers, some walling up caves and others hewing rooms out of the rock in the rear of the built structures. Of such kind were Puyé and the noted Frijoles Canyon, New Mexico. Similar rooms were crudely carved in the soft Tertiary limestone of the Upper Verde Valley in Arizona.[16] These, as cliff dwellings elsewhere, were supplementary to important sites above the cliffs, as at Puyé or on the valley floor below, as in Frijoles Canyon.

In Cappadocia, near the dry heart of Asia Minor, the troglodyte villages, such as Udj Assaru, Martchan and Urgub, have the same peculiar combination of semi-cavate, semi-cliff terraced and open villages as those of Puyé and Frijoles Canyon. In both cases the cliffs are easily carved volcanic tuff and the natural erosion forms are more accurately duplicated than even the dwellings.

Terraced villages built over summits or on slopes are common protective devices of the arid regions of the world. Striking examples are the Saharan Villages of Siwa and Ghardia and many Tibetan villages.[17] The Hopi villages, especially Walpi and the New Mexico pueblo of Acoma, piled up on the small rocky summit areas of cliff-bound mesas in Northern Arizona, have their peer in Yezdihast, Persia.

Cultural Modifications of Desertic Architecture

Practical considerations or purely decorative instincts have determined the lines of higher architectural development in dry sunny climes. On the simple fundamental lines already described, great distinctive architectural styles have developed around the Mediterranean Sea, the nursery of western cultures.

The larger structures of the ancients, as in Egypt, Phoenicia, Mesopotamia, Greece, etc., had to be roofed by the employment of great stone beams supported upon forests of massive stone columns. The desirability of outdoor life with protection from the sun has led to the development in all these climes of arcaded courts and walks. Even in the simpler Saharan towns and oasis villages, such as Bisra and Ghardaia, the graceful colonnades relieve drabness with a touch of beauty and comfort. Only in the hottest spots in our Southwest, as in Imperial Valley, California, and in Yuma, Arizona, has this compelling need for protection from the sun resulted in modern arcaded sidewalks on the main streets, giving these towns individuality. Unfortunately, lack of unity in style and bad taste have generally negatived artistic effect. In the great Spanish Missions of the Southwest, too, the colonnaded courts were a feature which have been much copied, chiefly for artistic effect.

The mud dome accompanies simple types, but in Roman and later Romanesque architecture the great masonry dome was combined with columns and colonnades or arcades. Byzantine architecture, at its best in Sanctia Sophia, Istanbul, is distinctive for its delicate ornamentation of flat walls with small window space as well as for its peculiar style of dome. The Saracens added further modifications, as the horseshoe and pointed arch, creating a style which is at its best in the Alhambra.

Among the Indians of the Southwest, as among the Spanish and Mexicans, the simple arbor or ramada described before, or with more finish, the Mediterranean pergola, is a simple expression of the same need for protection from the

[16] J. W. Fewkes, 28th Report of the Bureau of Ethnology, 1906–07, pp. 33–179.

[17] Illustration, *National Geographic Magazine*, p. 360, Vol. 53, March, 1928.

sun, where little shelter is needed from the other elements and where outdoor life predominates.

American Construction in the Arid Southwest

The early American settlers in the Southwest were effectively isolated from their fellows and adapted themselves to the country. In this period, the latter half of the nineteenth century, American and Mexican villages were hardly distinguishable architecturally. Sometimes even the early white settler had to start his new home with a crude wattle shelter like those of the Indians. Even as late as 1877 the first Mormons, coming into southern Arizona and settling on the Salt River, had at first to imitate their Indian neighbors along the river, using the material close at hand. Some of these first shelters had one room with low dirt floor and walls of arrow-weed and poles plastered with mud. An old settler describes as follows the home of the first couple to be married in the settlement. "It was built on four cottonwood posts set in the ground and logs put across on top about two feet apart, covered in brush and straw so as to hold the dirt on the roof. There must have been ten or more wagon loads of dirt on the roof. The sides were boarded with lumber." This house probably originated as a simple brush shed through summer and with the coming of winter was transformed into a more sheltered affair. Prescott, the early capital and metropolis of Arizona, was different in its highland environment of cool climate and pine trees. Early writers described it as like a New England village. But not so the desert settlements, Tucson, Phoenix, Florence or Yuma. Even today the old adobe houses predominate in the older quarters, which have now become the Mexican quarters. These early settlements and settlers were effectively isolated from the culture and its materials whence they sprung. Of necessity they adopted the indigenous desert house and adapted themselves to the conditions found in the desert, much as the Indians and Mexicans had done before them.

Throughout the state of New Mexico, with its predominant Spanish and Mexican population, the villages are nearly all made up of the low one-storied rectangular mud houses. The church, with its earth or frame tower mounted by a cross, is always the dominant and only conspicuous structure of the village.

In the Salt River Valley of Arizona, which now includes about 30 per cent. of the population of the state on less than 1 per cent. of its area, three distinct periods of architecture are in evidence. Phoenix and Tempe were the only settlements of any importance in the valley in Arizona's early historical chapters, and even they in their earlier days were entirely subordinate to places elsewhere in Arizona. The old villages of Phoenix and Tempe were mostly of flat-roofed buildings. With the subsequent rapid settlement of the valley this type of architecture was entirely subordinated.

Following the building of the Southern Pacific Railway, which entered the state in 1878, there was an influx of settlers into the valley who came too rapidly to be assimilated by the indigenous culture. Swifter and cheaper transportation brought also building materials to which the new settlers had been accustomed, and a new period of lumber and brick construction was ushered in during the eighties.

However, this was before the day of general refrigerators and electric fans or of easy escape from the summer heat to the neighboring highlands by auto over smooth highways, and building construction had to be adapted to making the best of the long season of excessive heat. Winters were short and mild and made few demands and made possible lighter construction. Adequate facilities for heating, even in this sub-tropical

climate, were commonly neglected, the cheerful but inefficient open fireplace playing the principal rôle.

Most of the farm houses of the valley were built in this period. The inside arrangement of rooms on both sides of the wide hall was according to the conventions of the period, but the arrangements for outdoor sleeping with unscreened porches on one, two, three or all sides of the house was a conspicuous adaptation. High ceilings and attics protected the lower story or stories. The larger and better houses were built with two stories, but the typical house had one story with an attic, under a long square diamond roof sloping down over the screened porches on three or all sides.

In the town, roofs or porches commonly extended over the sidewalks, providing the best possible comfort to pedestrians and loafers. Hotels, like houses, provided outdoor sleeping quarters, and openly exposed sides and fronts were faced with verandas for each story. Each room had its door opening upon the sleeping porch, shared by all. Lack of privacy in sleeping quarters has never been immodest in Arizona, as considered in other parts of the country, and night dress was modest there long before the day of motion picture display and street pajamas. The street porch is for many of the older humbler village houses still the family sleeping room. The adaptations of this period were utilitarian but inartistic, with rusty screens and weather-beaten canvas shades on the porches, and the sidewalks covered with narrow roofs heterogeneous in height and angle, supported by slender posts or props. Yet there was an inviting hospitality about the old style house with its cool verandas and in the covered sidewalks, inviting to loiter and to loaf.

The modern metropoli of the desert, such as Phoenix, Tucson and El Paso, have developed rapidly in late years, along the most modern lines, chic, fresh and new, in imitation of the Southern California towns. The easy hospitality of the clime, expressed in their older styles, has given way to brisk commercialism. The sheltered sidewalks have almost disappeared. These cities would by their dress belie the summer heat, but what an opportunity is lost for individual expression of fitness to environment, both comfortable and artistic. There are local suggestions for pleasing, harmonious and utilitarian planning in the arcades and towers of San Xavier Mission near Tucson, in the terraced pueblos of the Indians and in the "Governor's House" of the Spanish period in Santa Fé. In the latter city there is much construction in imitation of the Spanish and the Indian pueblos but no concerted plan.

In these desert oasis cities of recent rapid growth there are rows of attractive appearing small homes built without regard to summer comfort in imitation of styles developed in other climes. However, the better-built homes now incorporate insulation wall materials, and the larger and better public and commercial buildings and hostelries have installed systems of air-cooling, permitting greater independence of form. So while in the future the desert climate will continue to impinge upon the evolving culture of the arid Southwest, the resultant distinctive qualities of the architecture may be more in the internal structure and in the use of special appliances rather than in the external expression of form.

FREEDOM OF THOUGHT IN ASTRONOMY

By Dr. OTTO STRUVE

DIRECTOR OF THE YERKES OBSERVATORY

On the 22nd of June, 1633—a little more than three hundred years ago—an old man, weakened by months of imprisonment and almost daily questioning, and whose eyesight was rapidly failing, knelt before a jury of ten cardinals who had been appointed by Pope Urban VIII, at the Dominican Church of Santa Maria Sopra Minerva, in Rome. A large assemblage of prelates and dignitaries of the official Roman Catholic Church had gathered for the occasion. The old man wore the black ecclesiastical gown of a professor and every one in the audience knew him, for he was the professor of astronomy at the University of Pisa and one of the greatest scientists of all ages, Galileo Galilei.

The meeting was a special one: he had been summoned for the public pronouncement of a sentence for the teaching of heretical and untrue doctrines. And as he knelt there on the stone slabs of Santa Maria Sopra Minerva, there must have entered his mind a picture of another great man of science, who thirty-three years earlier had been tried for the same heretical belief that the earth was moving around the sun instead of being in a fixed position. On the 9th of February, 1600, the philosopher and astronomer Giordano Bruno, of Nola, had been excommunicated and turned over to the authorities with the request that "the punishment be merciful and without shedding of blood." A week later he was publicly burned at the stake on the Campo di Fiora, refusing in his last moments the consolations of a priest who tried to hand him a crucifix.

The accusation against Galileo consisted of "holding as true a false doctrine taught by many, namely, that the sun is immovable in the center of the world, and that the earth moves, and is also with a diurnal motion." This doctrine was pronounced by the judges as "absurd, philosophically false and formally heretical, because it is expressly contrary to the Holy Scriptures. . . ."

Having been threatened with torture, Galileo was finally compelled to declare: "I abjure, curse and detest the said errors and heresies and generally every error and sect contrary to the said Holy Church; and I swear that I will nevermore in future say or assert anything verbally or in writing which may give rise to a similar suspicion of me; but that if I shall know any heretic or anyone suspected of heresy, I will denounce him to this Holy Office or to the Inquisition and Ordinary of the place in which I may be."

The story is told that when Galileo rose from his knees after having read the humiliating abrogation of the results of half a century of his work in astronomy, he murmured the famous words "E pur si muove!"—"Nevertheless, it does move!"

Galileo was released from the prison at Rome, but remained under the surveillance of the Inquisition, and his books, even those which did not deal with the Copernican system of the world, were prohibited and for many years could not be printed either in Italy or in any of the other Catholic countries.

Almost three hundred years after the trial of Galileo, in the year 1930, a self-appointed jury of twenty-one astronomers gathered in the offices of the Astrophysical Institute in Moscow and issued a proclamation, in the form of an open letter to Pope Pius XI at Rome. This, in effect, was as follows: He, the Pope, the infallible Vicar of Christ on earth,

is the direct successor in a line of twenty-four or twenty-five heads of the Catholic church, and is therefore responsible for the actions of his predecessors. Does he approve of and support the actions of Climent VIII, Paul I and Urban VIII under whose authority Giordano Bruno, Galileo and many others were persecuted, or will he openly denounce the actions of his predecessors "as being more vile than have been committed by all the criminals of the world together"?

The rôles had changed: the church is now the accused, and the astronomers sit as judges, but the nature of the accusations is startlingly similar. We note the same hostility, the same narrowness and the same intolerance in 1930 as in 1633!

And to make it clear that the attack was not directed merely against the Pope, the commentary to the letter states that "heretofore no one has dared to connect these acts (of inquisition, cruelty and terror) with that system of mental enslavement which is propounded by all churches, including the Vatican."

It is an established fact that in Communistic Russia, a country occupying a considerable portion of the surface of the earth and having a population of one hundred and fifty million, astronomy has been definitely charged with the task of destroying all religion. In observatory reports and in general articles in scientific journals we find that anti-religious propaganda has become one of the duties of an astronomer.

We might be inclined to ignore the anti-religious propaganda in Russia, were it not for the fact that this propaganda is systematically and persistently directed towards other nations. Thus in the *Russian Astronomical Journal* (Vol. 9, p. 125), we not only find an appeal to "all the scientists of the world" to "actively defend the Soviet Union" and to form a "close and steady alliance with the revolutionary proletariat," but we are told that in the capitalistic countries "the search for a synthesis degenerates into an appeal to religion, that is, to an illusory solution at the price of the capitulation of the scientific mind." Time and again the Soviet scientists are instructed not to "display a blind acceptance of the bourgeois authorities of America and of Europe," who fall into religious mysticism and are therefore unable to advance science.

It is astounding that after denouncing such men as Sir James Jeans, Erwin Schrödinger and others, for their "cowardly idealism," the spokesman for the Russian astronomers advises those who have not had the benefit of the class-war to guide them along the path of pure materialism, to develop their astronomical work along the lines laid down by such "authorities" as Lenin, Stalin and the father of the method of dialectic materialism, Hegel.

Lenin and Stalin are regarded by many as great statesmen and able economists, but it seems surprising that even their most loyal supporters would regard them as authorities in astronomy. To drag them into a field of science which they have never even attempted to study is as unreasonable as the dogmatic faith of Galileo's judges in the teachings of Aristotle!

Hegel, on the other hand, is well known to astronomers. In his famous philosophical treatise, "Dissertatio Philosophica de Orbitis Planetarum," he proved that there could be no planets between Mars and Jupiter and ridiculed the astronomers for their search of such objects. The number of planets, he stated, could not exceed seven, and he exposed "the folly of certain devotees of induction who sought a new celestial body merely to fill a gap in a numerical series."[1] Even while this "Monumentum insaniae saeculi decimi noni," to use the words of the Duke of Sachsen-Gotha, was being written, the Italian astronomer Piazzi discovered, on January 1, 1801, the first planetoid Ceres.

[1] Clerke, "History of Astronomy," p. 73, 1903.

It is amazing that after this colossal failure, Hegel is being thrust upon a pedestal for astronomers to imitate. I shall not quote here the opinions of two of his greatest contemporary astronomers, Gauss and Schumacher, but those who are interested will find a complete account in Wolf's "Geschichte der Astronomie" (p. 685, 1877).

The statement of the Soviet astronomers addressed to Pope Pius XI, though probably written and promoted by what we might call "political bosses" whose connection with pure science is less than casual, was signed by more than one hundred astronomers. Among them are men who are truly great and whose opinions can not be ignored. Whether we agree with them or not, whether we suspect that pressure has been exercised in obtaining their signatures, the fact remains that here is a large group of scientists who are avowedly opposed to all religion.

Under the circumstances, I can not agree completely with Dean Inge, who in his presidential address at the Conference of Modern Churchmen on "The Scientific Approach to Religion," held at Oxford in 1924, made the following statement: "The new desire for mutual understanding between science and religion, the weakening of the old dogmatics on both sides is a most happy feature of our generation." I am afraid that the "old dogmatics" have not been entirely outlived, and that intolerance, blind faith in authority and far-fetched accusations exist in 1933 as they did in 1633!

It might be thought that the recent outbreaks of hostility against religion in Russia and the even more recent outbreaks against Christianity in Germany are merely reflections of the post-war confusion which has upset the world since 1918. But that is not true. I quote from the book, "The Church and Science, a Study of the Inter-Relation of Theological and Scientific Thought," by Hector Macpherson:

> There can be little doubt that, speaking generally, science and religion were mutually hostile in the latter half of the last century. It is true that many of the greatest men of science were profoundly religious men; it is equally true that many leading churchmen . . . were broad and tolerant in their attitude to science, and were, indeed, sympathetic to scientific progress. Many scientific pioneers were themselves churchmen. While conceding this, the fact remains that the general attitudes of science and religion were wide as the poles asunder. The general belief was that the men of science, by finding natural explanations for such events as the origin of the earth, the origin of life and the origin of man, had driven God out of the cosmic process; and so the typical theologian rejoiced when scientific explanations broke down, and when scientists were divided among themselves. . . .

It might interest you to know that the author of this quotation is himself a minister in a church at Edinburgh, Scotland. A member of the Royal Astronomical Society, he has written numerous books on astronomy and related subjects. His book,[1] "The Church and Science," has been freely used in the preparation of this lecture, and I should like to recommend it to all interested persons for its sound and commonsense interpretation of many questions.

Although there has been an agelong controversy between astronomers and the church, it would be erroneous to conclude that astronomers have been predominantly irreligious. Galileo in a letter to his friend, Castelli, dated December 21, 1613, expressed his opinion as follows:

> As the Bible, although dictated by the Holy Spirit, admits in many passages of an interpretation other than the literal one, and as, moreover, we cannot maintain with certainty that *all* interpreters are inspired by God, I think it would be the part of wisdom not to allow anyone to apply passages of Scripture in such a way as to force them to support as true any conclusions concerning nature, the contrary of which may afterwards be revealed by the evidence of the senses, or by actual demonstrations.

[1] Published in 1927 by James Clarke and Company, 9 Essex Street, Strand, W. C. 2, London, as a part of the series "The Living Church," under the editorship of Professor John E. McFadyen, of Glasgow.

Who will set bounds to man's understanding? Who can assure us that everything that can be known in the world is known already? . . . I am inclined to think that Holy Scripture is intended to convince men of those truths which are necessary for their salvation, and which, being far above man's understanding, cannot be made credible by any learning or by any other means than revelation. But that the same God who has endowed us with senses, reason and understanding does not permit us to use them and desires to acquaint us in another way with such knowledge as we are in a position to acquire for ourselves by means of those faculties, *that*, it seems to me I am not bound to believe, especially concerning those sciences about which the Holy Scriptures contain only small fragments and varying explanations. . . . I think that in discussing natural phenomena we ought not to begin with texts from Scripture, but with experiment and demonstration, for from the Divine Word Scripture and Nature do alike proceed.

Similarly, many other noted astronomers of all times have combined religion with science and have seen no self-contradiction in this attitude. Copernicus was a monk. Gassendi, a French-Catholic priest, announced some twenty years after Galileo's trial that he would have accepted the Copernican doctrine had it not been declared by the church to be opposed to Scripture. Cassini, the first director of the Paris Observatory, founded in 1667, did not declare himself in regard to the Copernican system. He and his successors were devoted Catholics and established a private chapel in the building of the Paris Observatory where a priest read mass in times of sickness in the family. The German historian and astronomer Zinner states that the majority of astronomers have been religious men; but the tendency at the present time is probably to drift away from the formal churches.

What, then, has been the origin of the controversy? Its roots lie buried in history. Astronomy, the oldest of the sciences, originated as a part of religion. In Egypt, where the sky is clear much of the time and where the stars are more striking to the eye than they are in northern latitudes, astronomy became intimately connected with worship. The god Re was associated with the sun, while the goddess Isis was symbolized by the bright star Sirius. Sirius is visible at this time of year[2] in the southwestern sky, after sunset. Later in the year, in May and June, the apparent western motion of the sun renders it invisible, and early in July it can again be seen, in the early morning just before sunrise. The Egyptian priests watched patiently, night after night, for the first appearance of Sirius in the morning sky. It served as a calendar for them, and indicated that the Nile might be expected to start its yearly flooding of the valleys, upon which the crops, and therefore the existence of the Egyptians, depended.

Thousands of years before our era the Egyptians had developed a conception of the universe unlike that of most other nations. To them the universe was like a shell, with the earth at the bottom and the sky above it. The earthward face of the sky was sprinkled with lamps, hung from cables, which were extinguished during the day. The sun was a disk of fire traveling on a riverboat around the world.

A somewhat similar conception of the world was held by the Chaldeans.

The Hebrew version of the universe is contained in the Book of Genesis. The earth is conceived as a flat disk surrounded by water. Above the earth is the firmament, a solid and transparent vault, allowing the light of the stars to penetrate, and above the firmament is a vault containing the "upper waters," from which come rain, hail, snow and wind. The sun, moon and stars are supported above the "upper waters." A thorough study of the conception of the universe in the Bible was made by the Italian astronomer Schiaparelli in a book entitled "Astronomy in the Old Testament."

[2] April, 1934.

The old Mosaic cosmology, as pictured in the Book of Genesis, remained the doctrine of the official church. However, as Macpherson remarks, two other doctrines were simultaneously held by the Christian Church in the Middle Ages. There was the Aristotelian theory, which conceived the earth as a spherical body located in the center of the universe. The various celestial bodies were imagined as being attached to transparent spheres revolving around the earth. Then there was the Ptolemaic system, which discarded the concentric spheres of Aristotle and assumed that the planets moved in epicycles. The theory of Ptolemy was astronomically far superior to the other two, but it seems to have been held by only a small minority of educated people in the Middle Ages. Thomas Aquinas and Roger Bacon had adopted it.

It is difficult to understand why the system of Aristotle should have been made almost a dogma by the church of that time. In many respects it contradicted the story of the Bible, yet it does not seem to have met with much opposition when it was introduced into Europe by the Arabs. As Macpherson puts it, "The only bond of agreement between the three conceptions was the supreme and central place which each of them assigned to the earth."

This idea was badly shaken by the work of Copernicus. By abandoning the central position of the earth he was able to simplify the theory of Ptolemy and to free it of the complications produced by the epicycles. Though started thirty years earlier, the great work of Copernicus, "De Revolutionibus Orbium Coelestium," was not published until 1543, the year of his death. He was afraid of the reception it might receive on the part of the church.

However, neither he nor his great successor Kepler seem to have been molested for their cosmological ideas, though both the Catholic and the Protestant churches rejected them. Martin Luther referred to Copernicus as "an upstart astrologer, who strove to show that the earth revolves, not the heavens or the firmament, the sun or the moon. . . . His book wishes to reverse the entire science of astronomy; but sacred scripture tells us that Joshua commanded the sun to stand still and not the earth." Melanchthon and Calvin made similar remarks: "Who will venture to place the authority of Copernicus above that of the Holy Spirit?"

The controversy was enhanced by the epoch-making discoveries of Galileo. In 1608 an apprentice working in the optical establishment of Hans Lippershey in Holland was playing with some spectacle lenses and happened to look through two of them held a certain distance apart. He noticed that objects seen through the lenses appeared enlarged and reversed. A few months later Lippershey was given a reward of 900 florins for the discovery of the telescope.

In 1609 vague reports of the Dutch discovery reached Galileo in Italy, and after some experimenting he succeeded in rediscovering the principle of the telescope. In the same year he began his astronomical observations.

To his great surprise he found that the moon was covered with mountains and that the planets appeared as tiny disks, while the stars were greatly increased in number, but were not noticeably increased in size. The discovery of four moons traveling around Jupiter was especially startling and gave a visible miniature of the Copernican system.

It was on January 7, 1610, that Galileo turned his telescope on Jupiter and noticed three fairly bright stars in a line with the planet, two of them being to the east and one to the west. On the following evening all three were on the west side of Jupiter.

The significance of this discovery is brought out by the following words of Galileo:

We have a notable and splendid argument to remove the scruples of those who can tolerate the revolution of the planets around the sun in the Copernican system, yet are so disturbed by the motion of our moon about the earth, while both accomplish an orbit of a year's length about the sun, that they consider that this theory of the universe must be upset as impossible; for now we have not one planet only revolving about another, while both traverse a vast orbit about the sun, but our sense of sight presents to us four satellites circling about Jupiter, while the whole system travels over a mighty orbit about the sun in the space of about twelve years.

Galileo referred here to the system of Tycho Brahe, the last of the great observers before the invention of the telescope, who postulated that the planets moved around the sun, but that the latter revolved around the earth, which was fixed in space.

Galileo's discoveries were immediately attacked on all sides. The moon could not possess mountains, it was argued. Sizzi, an astronomer in Florence, denied the existence of the moons of Jupiter, because of the sacred nature attached to the number seven: did not man possess seven windows in his head? "Moreover," he states, "these satellites of Jupiter are invisible to the naked eye and therefore can exercise no influence on the earth, and therefore would be useless, and therefore do not exist; besides the Jews and other ancient nations, as well as modern Europeans, have adopted the division of the week into seven days, and have named them after the seven planets (Sun, Moon, Mercury, Venus, Mars, Jupiter and Saturn). Now, if we increase the number of planets, this whole and beautiful system falls to the ground."

Sizzi and others refused to look through the telescope, probably fearing that they would be deceived by some diabolical trick.

No less severe were the attacks upon Galileo's discovery of sun-spots. The fact that the sun was not uniformly brilliant seemed to upset the idea of the perfection of the exterior universe, which was one of the basic principles of Aristotle.

The sun-spots were independently discovered by the Jesuit priest Scheiner, and Macpherson relates that when Scheiner announced his discovery to the provincial general of his order the latter replied:

I have read the whole of my Aristotle several times, and I can assure you I found nothing similar there. Go, my son, quiet yourself, and be certain that there are defects in your glasses or in your eyes which you take to be spots on the sun.

In spite of the opposition of the church the Copernican system was soon generally accepted. Officially the books of Nicolaus Copernicus remained prohibited until 1822.

The Copernican system found its greatest support in the theory of gravitation of Newton, published in the middle of the eighteenth century. The universal force of attraction, which acts equally on the earth, the sun and the stars, provided the clock-work which was required to keep the planets moving in accordance with the famous three laws of Kepler. But Newton was unable to account for the origin of the motions. Gravity could maintain them, but could not start them. Newton thought that God had arranged these motions and that He from time to time intervened in order to correct the irregularities which arise by the actions of planets and comets upon one another.

This view received a setback when Kant, Laplace and Herschel advanced the nebular hypothesis of the origin of the universe. They attempted to show that the motions in the solar system had developed gradually as the result of the continuous action of physical laws upon a chaotic nebular mass. The idea of a primitive creation as imagined by Newton was thus rendered unnecessary, though no attempt was made to account for the original nebula.

No wonder that "throughout the theological world there was an outcry at once against atheism, and war raged fiercely."[3]

Nevertheless, the ideas of Laplace and Herschel were later developed by other astronomers, and cosmogony now constitutes an important part of astronomy.

It is, I think, clear to us now that the long-enduring war between the church and astronomy was due to misunderstanding. Had the spheres of science and religion been properly divided in the days of Galileo, there would have been no discord.

In conclusion, we might ask whether the history of astronomy gives us an indication of its future. The errors made by theologians and astronomers of the past, though glaring when seen in the light of present-day knowledge, were the result of the chaotic state of civilization in the Middle Ages. There is no doubt that the men on both sides of the controversy were honest and were genuinely following their convictions.

Is it not possible that we, in the twentieth century, are prone to repeat the mistakes of our ancestors of the seventeenth century? Should we not profit from their experience and urge upon a world distracted by the economic evils following the great war, and tending towards extreme chauvinism, that *only tolerance and respect for the opinions of others can save us from a repetition of the mistakes of the past?*

It seems to me that this is the only conclusion in which we are justified. Astronomy does not undertake to dictate what nor how we should believe. It is not directly concerned with religion, but leaves the astronomer free to form his beliefs as would a member of any other profession. Having made this concession, he has a right to expect that his freedom of thought will not be interfered with by political, religious or other non-scientific interests.

His work consists of the search for truth, and he should not permit prejudices to inferfere with the freedom of his mind. He may, if he wishes, search for law and order in the universe, but he should not presume that absolute order must necessarily exist. He may marvel, if he likes, at the beauty and intricacy of the structure of the galaxy, but he should not assume in advance that there *must* be either beauty or intricacy. Laymen often speak of the "purpose" evidenced in the astronomical universe. An astronomer is justified in attempting to find whether the stars really give evidence of a purpose comprehensible to our minds. But remembering the successive steps of Gassendi, to whom the Copernican system was unacceptable because it did not comply with the Scripture, and of Newton, who evoked the remark by Leibnitz that his world-system appeared to be like a clock which required the frequent interference of the watch-maker, the astronomer would do well not to start out with the preconceived idea that he is bound to discover an understandable purpose or a universal power in the galaxy.

At the same time, no one knows better than does the modern astronomer that our knowledge of the material universe is limited on all sides. Recent work on the "Expanding Universe" by Slipher, Hubble, Eddington, DeSitter, Einstein and Lemaître has brought us to what now seems to be a wall. What lies beyond the wall and what may be concealed within the idea of a curved universe is for the present a mystery.

[3] A. White, "Warfare of Science with Theology," I, p. 18.

THE THIRTY-HOUR WEEK

By Dr. HAROLD G. MOULTON
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AMONG the many remedies which have been proposed to overcome the depression none is more far-reaching in its potential effects upon the welfare of the people of the United States than a thirty-hour week in industry. It is safe to say that no legislative proposal has ever been advanced which is more revolutionary in its economic and social implications. Its appeal to the public is based on the universal desire for immediate recovery, and for greater security of employment in the future, with more leisure in which to enjoy life.

A higher standard of living—with more goods and services for everybody and more time in which to enjoy them—has long been the goal of society. Great progress, moreover, has been made in this direction during the past few generations. In the thirty-year period from 1900 to 1929 the working hours in American industry were reduced on the average from about 57 to approximately 50 hours per week. While this 13 per cent. reduction in the length of the working week was occurring, there was a rise in the per capita income of the American people of approximately 40 per cent. All classes shared in this improvement.

Important as has been this gain, few would be satisfied with the results thus far attained. The goal for the years which lie ahead should be a rapidly increasing productive efficiency which would make possible still further reductions in hours and a more abundant distribution of goods and services for the satisfaction of human wants than has ever been accomplished in the past. Everybody cherishes the same goal; differences of view arise chiefly in connection with the ways and means by which recovery and continued economic progress are most likely to be achieved.

In view of the fundamental character of the proposal for a thirty-hour week it is not surprising that many people have looked upon it with serious misgivings and attacked the very premises on which it is based. It has become, in fact, a primary national issue. It is therefore important that an analysis of the economic implications of the problem be made at this time. Would it bring the material benefits which its advocates believe, or would it precipitate new difficulties and further lower already reduced standards of living?

THE BACKGROUND OF THE MOVEMENT

The thirty-hour week proposal was advanced before the coming of the Roosevelt administration. In fact, bills had been introduced in the preceding session of Congress in the form of measures to prevent interstate or foreign commerce in products of industrial enterprises in which workers were employed more than five days a week or six hours a day. These bills, however, as well as those introduced by Senator Black and Representative Connery in the spring of 1933, did not definitely propose the maintenance of existing weekly wages. These measures simply sought to compel a wider distribution of whatever work existed and were in line with the "share the work" movement which had attained some importance as a volunteer program.

The Black Bill passed the Senate by a vote of 53 to 30 on April 6, 1933. The Connery Bill, which varied only slightly from the Black Bill, failed to reach a vote in the House—being replaced by the measure for national industrial recovery. The coming of the Recovery Administration shifted attention from a uniform reduction of hours to such varying limitations of the work week as might be achieved through industrial codes.

A new bill, however, was introduced by Representative Connery in the 1934 Congress, which provided that all NRA codes should be subject to the thirty-hour week—which would mean a reduction of about one fourth from the average which had been obtained under the codes. A provision was also incorporated for the maintenance of existing weekly wages. It is the principle of the Connery Bill that is now under public consideration. It is likely to reach the stage of active legislative discussion in the coming session of Congress.

The Underlying Philosophy

The philosophy underlying the thirty-hour week is rooted in part in conditions arising in and growing out of the depression, and in part in certain fundamental assumptions with respect to the existing state of development of the economic system. The primary ideas may be briefly indicated.

The relation of the thirty-hour week proposal to the problems presented by the depression involves two distinct phases or aspects. At first, it was looked upon as a way of alleviating the distress of the unemployed. In the absence of any comprehensive governmental program of relief, and with private charity incapable of caring for the situation adequately, the spreading of employment was regarded as a means of meeting the crisis. Under this share-the-work plan, the burden of helping one's fellows would be borne directly by those whose hours of work were shortened.

Later, it was argued that the thirty-hour week might be made the means of breaking the depression itself. To accomplish this result it would be necessary to reduce the working week without an accompanying reduction in pay. A shorter working week, it was reasoned, would thus not only absorb unemployment but, by increasing aggregate payrolls, would expand purchasing power and help in a powerful way to "prime the industrial pump."

In its longer-run aspects the thirty-hour week was conceived to be possible, if not indeed essential, in the light of the great productive capacity which this nation has developed. The attention which so-called "technological unemployment" had attracted even before the depression gave rise to the thought that if we were to avoid permanent unemployment on a large scale it would be necessary to absorb displaced labor by progressively shortening the hours of work. Tremendous emphasis was given to this aspect of the problem by the assertions of the "technocrats" that the country's productive capacity is even now superabundant and that if given a chance it will soon render human labor largely obsolete.

The conclusion has been drawn from such discussions as these that this country has passed from an era of scarcity to an era of potential plenty; we now have, it is widely believed, a "surplus economy." The primary source of our economic difficulties, according to this conception, is excess productive capacity. A shorter week is thus regarded as desirable as a means of bringing about a better adjustment of supply and demand.

The thirty-hour week is also not unnaturally advanced as a means of furthering the cause of labor as a special group. A reduction in working hours,

rendering labor more scarce, would, it is believed, improve the bargaining position of employees and enable them to obtain progressively higher wages in the future. This, it is argued, would promote a better social order—through a better distribution of income. It is believed that scarce labor and high wages would prevent excessive profits and provide the larger income for the masses which is essential to the full utilization of productive capacity.

Analysis of the Underlying Philosophy

In considering the basic ideas underlying the thirty-hour-week plan it is necessary to break the discussion into two parts. It will be useful if we consider first the fundamental assumption that this country is suffering from a chronic state of over-production.

How great is our productive capacity? The Brookings Institution has recently made an exhaustive investigation of the productive capacity of the United States and the relation of this capacity to the consumptive demands and wants of the people.[1] The conclusions may be very briefly summarized.

In 1929, the last year before the depression set in, the actual output of goods and services had a value of approximately 81 billion dollars. The possible output—with the organization of economic activities then prevailing and with the capital supply and labor power then available—was approximately 97 billion dollars worth of goods and services. In making this estimate account was taken of the numerous practical considerations which operating industry has to face, such as seasonal factors and the requirements of changing styles. This figure, then, represents the practical capacity under the economic organization then existing.

Was production adequate to supply satisfactory living standards? If distributed equally among the entire population, the 1929 production would have given to each person goods and services valued at about $665. Had we been able to operate at 100 per cent. capacity, the income per person would have been increased to about $800. Income, however, is not divided equally. In 1929 there were over 2,000,000 *families*, having incomes of less than $500; this amount had to support two or more persons—an average of at least four. There were about 3,800,000 families with incomes between $500 and $1,000, and more than 10,000,000 families with incomes from $1,000 to $2,000. As many as 16,354,000 families, or more than 60 per cent. of the total number, had incomes under $2,000. A family income of $2,000 scarcely provides for the basic necessities of life, and leaves little or nothing for comforts and luxuries.

Even if the total product of the nation were divided equally among the entire population, the average family income would have fallen short of the requirements of a wholly satisfactory standard of living. What we must have in the future is a much larger production of goods and services than we have ever attained in the past, if we are to realize the aspirations of the people.

How would the thirty-hour-week affect wealth production? It has already been pointed out that during the great period of technological advancement from 1900 to 1929 we succeeded in increasing per capita production by about 40 per cent. and in decreasing the working week by about 13 per cent. In 1900 the standard working week of wage-earners averaged approximately 57 hours. By 1909 the average had been reduced to about 55, and by 1919 to about 51.3 hours. During the decade of the 20's there was further gradual reduction, and by 1929

[1] See Edwin G. Nourse and Associates, "America's Capacity to Produce"; and Maurice Leven, Harold G. Moulton and Clark Warburton, "America's Capacity to Consume."

an average of about 50 hours was reached. There was, however, a wide variation among the different divisions of industry, running from around 44 hours in coal production and the manufacture of men's clothing to as high as 60 hours in some divisions of the iron and steel industry.

Since 1929 the standard working week has been reduced to an average of about 40 hours. The greater part of this reduction occurred prior to the NRA and resulted merely from the decrease in the average hours actually worked as operating schedules were curtailed. Under the NRA these shorter hours came to be incorporated, with modifications, in the various codes as the standard week. It appears, then, that there has been a reduction since the beginning of the depression by about 20 per cent., or substantially more than had occurred in the previous 30 years. The proposed further reduction to 30 hours a week would mean a total reduction for wage-earners[2] since 1929 of 40 per cent.

The question presents itself squarely —Can we maintain a level of production equal to that of 1929 on a 40 per cent. shorter working week for the major portion of American workers? It is evident that such a maintenance of output would be possible only provided there has been a corresponding increase in productive efficiency during these years.

Available data indicate that there was in fact an increase in man-hour productivity in *manufacturing industries* between 1929 and 1934 in excess of 25 per cent. This was in some cases the result of improved operating methods and more efficient machinery. But it was more largely attributable, we believe, to two other factors which are temporary in character. The first was the spur to efficiency resulting from the fear of losing one's job when jobs were scarce; the second resulted from a selective process in connection with personnel which gradually took place as the older, less efficient and less well-trained workers were removed from payrolls as the depression developed. Another contributing factor was the disappearance of a large number of relatively inefficient business establishments. Just as soon as the less efficient personnel was reemployed, man-hour productivity would doubtless register a sharp decline. Only that increase which resulted from technological progress could be expected to remain permanent.

It is hardly to be believed that a comparable increase in man-hour productivity to that shown in manufactures has occurred in most other fields. In agriculture, transportation, building construction and the professional and domestic services, it does not appear that there has been an appreciable increase in productivity resulting from technological improvements. Such increase in man-hour output as has occurred in these lines is largely attributable to the temporary influences to which reference has been made.

Manufacturing industries account for only about 20 to 25 per cent. of the value of the total national output of goods and services. Hence, even if we assume that the recent increase in man-hour output in manufacturing lines were to be wholly maintained, the average increase in productivity in American economic life as a whole would appear to be less than 10 per cent.

We conclude that a reduction in the hours of work such as is contemplated would inevitably mean a volume of wealth production substantially below the levels obtaining in 1929. But it should be emphasized again that what this country needs is not less production but more.

[2] For salaried workers the reduction since 1929 has been much less. At present the average standard week for wage-earners in industries operating under codes is practically the same as that for salaried workers.

Would a better distribution of wealth be the result? One of the underlying ideas of the thirty-hour week, it will be recalled, is that it would make labor scarce, raise wages and thereby bring about a more equitable distribution of national income. We have just seen that the consequence would be a reduction in the total product to be divided. Assuming that a more even distribution of a smaller total income is preferable to a less uniformly distributed larger total which affords higher incomes for all, the question must still be raised whether the thirty-hour week would actually bring about a more even distribution of the national income.

Superficially, it may appear that if wage rates are increased the share of the total product going to the workers would rise and that the share going to profits would decrease. But the problem is not so simple as this. Rising wage rates increase costs and prices and when prices rise the relative share going to profits may be maintained or even increased. The experience under the NRA does not support the assumption that an increase in wage rates, resulting from shorter hours, increases the proportion of the total output of industry going to the masses. The relation of the increase in wage costs to prices will be discussed presently.

We now turn from these longer-run considerations to the relation of the thirty-hour week to the problem presented by the depression itself. We must consider first the desirability of a shorter working week for the express purpose of spreading employment and thereby alleviating distress.

Is a shortened working week a satisfactory means of relief? A reduction of the working week to 30 hours is certainly one method of taking care of the relief problem. In round numbers we have 30 million employed workers and 10 million unemployed. If we assume that the work week is reduced from 40 to 30 hours every unemployed worker could presumably be given 30 hours of work.[3] Since those to be brought in to share the work of those now employed would on the whole be less experienced and less efficient for the particular tasks in hand, their reabsorption in industry by means of the thirty-hour week would obviously mean a decrease in total industrial output and in the volume of goods and services available for supplying the wants of the people.

Other methods, or combination of methods, for affording relief are clearly superior to spreading employment. They are on the whole beset with fewer practical difficulties, they are more equitable and they do not lead to a reduction in total product. Any method of relief which provides new employment without interfering with the volume of output of those already employed has the positive advantage of adding to, rather than subtracting from, the total production of goods and services.

Would the thirty-hour week generate recovery? In addition to reabsorbing the unemployed, the shorter work week, as we have seen, has come to be conceived as a means of increasing total purchasing power and thereby stimulating business revival. The argument, in brief, is that the increase in total payroll disbursements would lead to increased purchases in trade channels, which would start the wheels of industry everywhere.

Conceding for the sake of the argument that the purchasing power theory of business recovery is sound, we must nevertheless ask whether an expansion of purchasing power by means of the thirty-hour week is a feasible means of

[3] The average number of hours actually worked by those employed, including part-time workers, is now less than 40 hours. Consequently, the spread of employment would not be as balanced as is suggested by the round figures here cited. It should be noted, however, that a 30-hour standard week would in practise mean an average of less than 30 hours of actual employment.

accomplishing the desired result. It should be clear from the analysis already made that a thirty-hour week would involve a simultaneous increase in wage rates and a decrease in productive efficiency. The volume of output would be declining at the same time that the payment of wages was increasing. This would perforce result either in bankrupting business or in a rise in prices more rapid than the expansion of payrolls. If the former alternative resulted, we obviously would not have recovery, but rather greatly intensified depression. In the latter alternative the rapid advance in prices would nullify the increased money wages.

In considering the relation of a reduction in hours to recovery, the inflexible character of the thirty-hour week must not be forgotten. Different lines of industry ordinarily have varying work schedules—adapted to the character of the labor involved, the arrangement of the machinery and the requirements of different processes of production. A rigid universal thirty-hour week, or for that matter any other set number of hours, would put industry in a straight-jacket and reduce efficiency. Even though in time business might possibly accommodate itself to an inflexible working schedule, the immediate effect would unquestionably be to retard recovery.

The Thirty-Hour Week and the Level of Prices

It is reasonably clear from the preceding paragraphs that a sharp increase in wages, accompanied by a decrease in average efficiency, would exert through increased costs a direct effect upon prices. Let us see just how great an increase in wage costs is implied. Under the NRA codes the average "standard week" in industry is about 40 hours. Assuming this standard to be the basis for computing weekly wages when the hours were reduced to 30, an increase in hourly rates of wages by 33⅓ per cent would result. If, however, the measure were applied on the basis of the actual hours worked at the time it took effect the average increase in wage rates would be somewhat less. This is because the actual length of the working week for industry as a whole is now appreciably less than 40 hours.

It is unnecessary to speculate as to the probable effects of such an increase in wage costs upon prices—for we have before us the comparable experience of the NRA. A study which the Brookings Institution has made of the effect of wage increases upon prices since the establishment of the codes shows that the prices of manufactured commodities and the wage rates of the labor engaged in the production and distribution of these commodities had roughly an equivalent increase.[4] Whether or not one thinks so extensive a rise in prices was warranted, it is none the less a fact; and it is a fact which has already apparently led to a material shift in point of view on the part of the Administration itself as to the practicability of the policies that have been pursued.

In the light of this experience, it would seem reasonable to believe that a further drastic curtailment of the working week would be followed by a commensurate increase in the prices of manufactured commodities. Indeed, in consequence of the decrease in average efficiency that would ensue, the rise in prices might well be more pronounced than was the case under the NRA codes.

It should be noted, however, that instead of recouping by means of an immediate rise in prices many business concerns might be confronted with serious immediate difficulties. In cases where prices could not be raised in anticipation of the increased costs, and where working capital is limited, it would be necessary to procure the funds

[4] "The NRA as a Recovery Measure," by George W. Terborgh (to be published in the near future).

with which to meet the enlarged payrolls by means of bank loans or the flotation of securities. It is scarcely to be doubted that the difficulties encountered during the past year, particularly in small industries, in procuring the funds necessary for increased operating costs would be greatly intensified by the establishment of a thirty-hour week.

Effects upon the Various Economic Classes

Assuming that the thirty-hour week could be installed on a national scale without throttling enterprise, it remains to trace its consequences. We shall consider first the effects upon various groups in the body politic and, second, its relationship to other phases of national policy.

1. *Wage-earners.* The thirty-hour week has been advanced primarily in the interests of the laboring class as a whole. Let us, therefore, consider just how it would affect the wage-earners. At first glance it would appear that, since there would be no cut in wages, the position of the worker who is employed would in no wise be impaired. The truth is, however, that his real wages would be appreciably reduced in consequence of the rise in prices. Everything that he purchased which was produced by industries operating on the thirty-hour week schedule would, as we have seen, be substantially enhanced in price. Moreover, there would be a tendency, for reasons already indicated, to freeze standards of living at the reduced level.

The special effects upon different wage-earners will depend upon the method used in establishing the plan. At present there is a great variation in working hours among individual employees, different plants and different industries. Thus, according to September, 1934, figures, the average in meat packing was about 43 hours per week, while in iron and steel it was less than 23 hours. If the measure were applied indiscriminately on the basis of the actual hours worked at the time it took effect, the workers in meat packing would obtain an average weekly wage based on 43 hours of work with added leisure of 13 hours, while those in iron and steel would presumably be left with average wages for a 23-hour week, with no possible increase of leisure.

2. *Salaried and fixed income groups.* It is not clear from current discussions whether the thirty-hour week would be made applicable to individuals working on salaries in industry and other occupations. If it did apply to them they would be affected in much the same way as wage-earners. They would have more leisure, but this would be at the cost of a lower real income. If the thirty-hour week were not applied to this class, they would have the lower standards of living without an increase in leisure. Individuals living on fixed incomes would be adversely affected to the precise extent that prices rose.

3. *Farmers.* The 30 million people constituting the agricultural population would likewise be adversely affected. It is hardly to be expected that those who are pressing for this measure contemplate a thirty-hour week for the farmer. Although the farmer would thus not get any more leisure, he would find himself confronted with higher prices for all the commodities he has to purchase. The rise in prices would affect him both as a consumer and as a producer. The rise in his operating costs would reduce his money income, and the purchasing power of this money income would also be curtailed as a result of the rising level of prices.

It should also be pointed out that certain types of industries would be adversely affected. Regulated industries, such as the railroads and public utilities, would be unable quickly to advance prices as wage rates and costs of pro-

duction increased. In consequence, earnings would be naturally reduced; and in view of the slender margin of profits now existing we might well expect a new epidemic of bankruptcies. In any event, it would prevent such industries from contributing toward recovery by increased expenditures for replacements and new equipment.

Relation to Other National Policies

Consideration must also be given to the possible effects of the thirty-hour week upon the government's program in general. Would it supplement other policies now being pursued, or would it tend to impede the national program of recovery?

First, the proposal obviously works at direct cross purposes with the government's agricultural program. The effort is being made to bring about a better adjustment between agriculture and industry through raising the prices of farm commodities relatively to the prices of industrial products. If the thirty-hour week were instituted, it would certainly defeat this objective.

Second, a thirty-hour week would tend to impede international commerce at a time when the United States is making a renewed effort to expand foreign trade. At this very juncture we are entering into negotiations with various foreign countries with a view to consummating arrangements for reopening the channels of international commerce—as a means of promoting world recovery. A sharp increase in American wages would be accompanied by an immediate demand for higher tariffs as a means of protecting the American market from a vast increase in imports of cheaper foreign goods; and as a practical matter all chance of effecting any adjustment of tariff rates by negotiation would be gone. In any case, the rise in costs and prices would increase the difficulties of American manufacturers in finding outlets abroad. Such a policy would thus work against a growth of exports and the increase of employment connected therewith.

Finally, it should be noted that this program ignores the experience gained under the NRA—with reference to the control of purchasing power, the safeguarding of the position of smaller industries, and the problems of regulation generally. In fact, the administration and enforcement of a thirty-hour week for industry generally would present far more intricate and baffling problems of policing and control than any yet encountered.

In summary, this analysis of the economic effects of the thirty-hour week clearly leads to the conclusion that the measure would not promote national welfare. It would prove detrimental to the interests of labor as well as other classes. It would not promote recovery and bids well to intensify the depression. At best its immediate effects would be a spread of employment at the expense of efficiency and productive output. In its long-run implications the measure offers to the workers of the country merely a choice between more leisure and a more abundant consumption of goods and services.

It goes without saying that it is the duty of the nation to prevent want among the unemployed. But to seek this end by a compulsory reduction of the hours of work, which would freeze the possible volume of production below the level required to give all the people the abundance they desire, is as shortsighted as it is lacking in understanding.

NATURALISTS OLD AND NEW

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I

LYELL, Davy, Faraday, Darwin, Pasteur, Helmholz, Galton—merely to list these and other great naturalists of the nineteenth century suggests the discoveries and the methods of thought which make living in the year 1934 more free, effective and happy than living in the year 1800. These men and their like literally have shaped what is finest and strongest in contemporary intelligence. Nothing, however, is more characteristic of these naturalists than their recognition that time would probably disclose flaws in their work. So we may feel sure that, were they living now, they would eagerly and hopefully examine what the Encyclopedia Britannica terms the "new" naturalism, and all the more because this outgrowth of the past thirty years points to remedying a flaw that pervades the older naturalism they followed and taught.

This flaw is well exemplified in Huxley's well-known essay, "Ethics and Evolution" (1894). Its theme is that man is at cross purposes with the "cosmic process" or nature. Man's "ethical purpose" is to establish a society where justice, peace and kindliness flourish. But his utmost efforts can only fence off a little garden within nature's measureless, menacing jungle, whose law is pitiless force. So man's progress, insists Huxley, lies not in imitating nature, but in fighting her. In the long run nature wins; but man must "play the man," never yielding, and finding his solace in the memory of noble deeds. Bertrand Russell's "The Free Man's Worship" (1923) almost repeats Huxley's thought of thirty years before.

A "new" naturalist, if at all versed in anthropology, must smile at Huxley's notion that man's social aims are inherently opposed to the method of nature. For it is through establishing justice within his society that man rises to be master in nature's "jungle." "Morals" that diminish power are unethical rather than unnatural. Upon the play of other natural forces man's social intelligence simply imposes a new "dimension," which is as "natural" as a flower or an earthquake.

In general terms, the "older" naturalism contrasts nature with man, and tends to stress the "aberrations" of man's make-up and outlook; of his emotions, his arts, his schooling, his traditions and his society. It thought of man's "mind" as "epiphenomenal"—looking from outside upon nature—"the external world." It demonstrated only the "*Descent* of Man." It stands in contrast with that humanism for which "the proper study of mankind is man," and which proclaims "there man begins where nature ends."

On the other hand, the "new" naturalism finds a synthesis and culminating of natural agencies in man's achievements, which mark the *ascent* of man in nature; it finds man's "mind" to be a unique mode of interaction between an attentive body and the rest of nature, itself a part of nature and, with all its aberrations, as "natural" as anything else. It stands in contrast not only with humanism but with every attempt to identify nature with merely physical

nature or with any other single mode or factor of nature.

W. L. Bragg approaches the "new" naturalism in his recent lecture at Cornell.[1] "We must think of the physical world around us as the footprints of something which exists in other dimensions as well, which has other qualities which are not physical and which no physical apparatus, however delicate, can measure" (p. 240). But Bragg falls short of the new insight when he says,[2] "history only exists as a record of miracles. . . . Apart from the miraculous, history and time have no meaning except as a system of labels" (p. 239). To him, evidently what is not physically intelligible is unintelligible—miraculous!

The application of intelligence and the appropriate scientific method to all that history records, with the consequent elimination of the "miraculous," and the indefinite broadening of scientific study to every factor in every event in nature, is, says John Dewey, in the succeeding article of the same issue of *Science,* "The Supreme Intellectual Obligation." This recognition of the plurality of factors in natural events, and the potential intelligibility of all of them in their relation to each other is the keynote of the new naturalism. All knowledge is knowledge of nature, it is natural knowledge; though there are many kinds of knowledge.

The older "naturalists" are great specialists who uncritically accept philosophical or religious accounts of man's mind and will which have long been current. As Dewey notes, our present social confusion is very largely due to this disregard by specialists of the broader aspects of nature. Social regeneration calls for less restricted scientific activity and for a sounder philosophy. In consequence the "new" naturalists are perhaps best known as philosophers or as scientists with a pronounced philosophic bent. I refer to such men as C. L. Morgan, S. Alexander and J. S. Haldane in England, and L. J. Henderson, H. S. Jennings, A. N. Whitehead and John Dewey in this country. But all these men have attained competence, and most have attained high distinction in some field of natural science. The new naturalism is no more philosophic than the old; but it expresses a self-conscious, critical and technically competent philosophy instead of one that is largely traditional.

Practically, what difference does it make whether we side with the older school of naturalism, represented by such men as Bertrand Russell, E. L. Thorndike, A. S. Eddington and J. L. Milliken, or with the newer school in which Sir James Jeans apparently has just enrolled,[3] with W. L. Bragg as an illustrious candidate for admission? Here my answer is restricted to a few definite examples, in which the older school, through their exclusion from nature of factors existent in nature, commit what has been called the fallacy of reduction, or the fallacy of "nothing but." Its consequences are not merely theoretical.

In his "The Modern Temper" J. S. Krutch rightly traces current pessimism in part to the view that ultimately nature is nothing but physical elements blindly moving under inflexible law. Krutch himself seems to accept this

[1] "The Physical Sciences," W. L. Bragg, *Science,* March 16, 1934.

[2] *Ibid.*

[3] The 1933 edition of "The Mysterious Universe." However, Jeans' presidential address to the British Association for the Advancement of Science, printed in *Science,* Sept. 7, 1934, shows clearly that, while he has now heard that "mind" is an activity in nature, he has not at all grasped the realistic consequence of this fact. His conviction that "mind" knows only its own ideas is exactly the idealism of Bishop Berkeley, in 1710.

view, disregarding the many factors in nature other than these elements. This view is, according to my observation, largely traceable to the false simplification with which is "explained" so "miraculous" a fact as the formation of water out of the gases O and H. The average college student accepts without question the suggestion that somehow water is "nothing but" H and O combined in certain proportions. A path toward making this "miracle" intelligible is taken when we emphasize that the properties of any physical unit are not simply located in that unit, but are the properties of the interaction and interrelation between that unit and the rest of nature. In this way the matrix, structure and disposition of nature are given due weight in physical science, so that a path is left open to rendering the actual wealth and variety of the cosmic process intelligible instead of "miraculous" and alien.

A second illustration is found in attempts, since the days of Clerk Maxwell, to reduce the processes of nature to simple thermodynamic terms. In most natural events we see going on at the same time both development and degeneration. In the former, as the historian of nature records it, complexity of organization and heterogeneity of material increase; while in the latter they decrease. Consider, for example, the development of a solar system or of our earth or of a living body. In each case degenerative processes also may be found; and at some stage in every development degeneration takes the upper hand. But in nature as a whole, or in any part of it, it is impossible to say that either development or degeneration prevails.

Now, in physico-chemical equations the degenerative processes alone are described. If the developmental processes, such as the building of animal tissues, are some day subjected to such mathematical analysis, we have every reason to expect that they will exhibit not a diminution of available energy, but an increase.[4] There is, therefore, no present reason to declare that the "universe" is "running down" or to inquire how at some time it was "wound up." The most eminent astrophysicists, none the less, observing in the universe nothing but the type of change they have learned to "mathematize," have filled books, newspapers and lecture halls with tales of nature "running down." The effect is to discourage the application of scientific method to the "developmental," vital aspect of life, since these are thus ignored by leaders in science; and so the solution is undertaken by clergymen! To the "newer" naturalism the developmental processes are as natural and obvious as the degenerative. The problem is simply how to formulate the former processes mathematically. If it is shown some day that their "mathematization" is impossible, the fact that *developments* actually and observably occur must remain as an ultimate fact in nature.

In his "Principles of Psychology," in his chapter on "Association," William James laid it down that "nothing but" a physiological explanation of thought could be accepted as scientific. This view, which was strenuously combated by many European psychologists, became traditional in American (and Russian) psychological laboratories. Pushed to an extreme, this view resulted in the dogma that learning is "nothing but" a combination of reflex-arc activity explicable through simultaneous excitation of arcs previously isolated. Imagine a schoolroom where this dogma

[4] "Development and Degeneration," H. S. Jennings, Yale University Press, 1934.

was accepted! Undoubtedly, in spite of its actual inapplicability to problems of learning, this dogma has diminished the scientific study of those many other factors in learning which good histories of learning or biographies make evident. Such factors as development of latent powers, insight into the relation between means and end, purposive application, imitation, sympathy, invention and imaginative glow can hardly be ignored by any practical person; but scientific study of these has been discouraged wherever the "older" naturalism prevails, with its arbitrary distinction between the physical facts of nature and the "confused human fancies" concerning them.

The newer naturalism delights in stressing the plurality of factors in learning, to correspond to the plurality of factors in the cosmic process that must be learned.

II

How in the world did it come about that for three centuries (1630–1930) the best minds identified natural science or the knowledge of nature with that type of learning and knowledge which reaches its climax in the laboratory of the physicist? The answer clearly is found in the extraordinary control of nature's resources that learning and knowledge of that type have secured us. Only in our own times has it become apparent to the thoughtful how man's life and purpose is distracted or enfeebled by learning that what for "humanism" is most evident and most significant is for natural science either "epiphenomenal" or "miraculous." This dualism has segregated intelligence into two camps, each so walled in by indifference or contempt for the other that even the interchange of abuse has suffered neglect.

Negatively, the menace of this dualism has been brought home by the inability of either humanism or naturalism of the older type to give an account of man's life that should fill the place in man's imagination and hope that is slowly being vacated by traditions of the supernatural. Positively, however, it is, as Bragg suggests, the work of the historian that has so interwoven the course of nature with the cultural development of mankind that every phase of man's life is now enriched and clarified by recognizing it as the working out of what was implicit in the natural conditions from which man's civilization emerged.

It was the metrical and deterministic emphasis of the older naturalism that compelled the humanists to harbor some sort of supernaturalism. The observation of the historian of nature has compelled the general recognition that qualities and values, individuality and organization play their part in the evolution of natural events, no less than the elements or the mathematical relations exemplified in them. And the multiplicity and distinctness of these several factors in history make not merely incredible but inconceivable the view that the course of nature or of man in nature is determined by one or by all of them.

So, instead of being a mind observing nature from without, or an accident occurring within nature, man to the historian is to-day becoming more and more a revelation of what the propensities of nature are. The antithesis between man and nature, or between nature and anything else whatever becomes increasingly difficult. The new naturalism invites us to lift up our eyes from any special field or method of observation, and in the first place to characterize the concrete events and entities from which all our knowledge is derived.

It is, I think, the peculiar service of

A. N. Whitehead that he has so defined these concrete events that the act of knowing falls under this general definition and so becomes in the fullest sense an event in nature.[5] His account does fullest justice to the "creativity" of nature and of individual entities in nature without succumbing to the mysticism of Bergson. His account of the objects of nature limits their rôle in nature without discrediting at all their actuality or the intelligence which makes these objects known to us.

In the second place, the new naturalism sets itself the task of denoting the several factors abstracted from events that are the theme of as many forms of natural knowledge, such as biology, mathematics and physics. The unity of nature is found not by reducing all factors to one, as in Haeckel's monism, but by showing that each factor implies and is immanent in all the others. This account of the matter disposes of the despairing view that what we know are mere phenomena or "pointer readings" of an unknowable transcendent reality, and makes us feel at home in and with reality itself throughout the adventure of science and knowledge.

It is too early to say whether this newer naturalism will actually stimulate and direct scientific inquiry. It may prove of more value to the scientist than to science. It looks toward an education through which specialists may speak to each other and to the rank and file of mankind with mutual comprehension. It marks the achievement of maturity by that western mind which has too long struggled with the contradictions between oriental dogma and the varied fruits of human experience. These latter now assume for the first time a certain adequacy for the direction of human enterprise toward natural ends.

5 "Adventures of Ideas," Chapter XI, "Objects and Subjects."

SCIENCE SERVICE RADIO TALKS

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DUST BETWEEN THE STARS

By Dr. JOEL STEBBINS

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THE question is often asked of the astronomer: How far can you see with your telescope? The answer is simple; one can see the Andromeda nebula with no telescope at all, and that is a million light-years away! Light traveling at the rate of 186,000 miles per second requires a million years to reach us from the nebula, and we now see the nebula as it existed there a million years ago. Put in another way, the flying time at 100 miles per hour for a distance of one light-year is 6,000,000 years; you could fly to the Andromeda nebula in a million times 6,000,000 years. The largest telescope in the world would be capable of photographing this nebula if it were removed to a thousand times its present distance, thus becoming a million times fainter. But the Andromeda nebula is intrinsically one of the largest and brightest in the sky, and we are not sure that any of the more distant nebulae are equal to this one in size or brightness. Therefore, the answer to the question about the present range of telescopes is that objects can be photographed which are more than 100 million light-years but probably less than 1000 million light-years distant.

The Andromeda nebula is one of the so-called galaxies; each galaxy looks to us like a hazy nebula but is made up of many stars. Remember the astronomical multiplication table: It would take a million earths to make one star. A thousand million stars make one galaxy, a thousand million galaxies make one universe. The sun and all the individual stars which we see, mostly in the bright band of the Milky Way, comprise our own galaxy. When we look out at the other galaxies, the question naturally arises: How nearly transparent is the space between us and them? Again the answer is simple. Between the different galaxies space seems to be almost perfectly transparent, but between the stars inside of a galaxy, especially inside of our own, there is good evidence that light is partially absorbed or obstructed. At first thought it might seem impossible to tell whether a star appears faint because it is far away or because some of its light is absorbed or obstructed by dark material in space. If there were no change in the quality of the star's light we could not tell about the obstruction, but if we find that part of the light is missing, as shown by a change in the color of the star, then something must have happened to the light in transit.

We all know how the sun appears more of a yellow or even an orange color when low down than when it is high up in the sky; at sunset it is reddest of all. Amateur photographers know that they must give increased time of exposure to take successful pictures when the sun is low. With a sensitive instrument we could, in theory at least, tell the time of day by measuring the color of the sun, which changes roughly from orange at sunrise to nearly white at noon and then

back to orange again at sunset. This coloration of the sun is due to the air molecules and dust particles which scatter the blue light more than the red, and when we look through an increase of air we see less blue, that is, relatively more red. Similarly, in certain directions in space there are stars which are really white or even bluish white but which appear yellow or red. One difficulty is to distinguish between distant white stars which appear yellow through the dust of space and nearby yellow stars seen in the clear.

Our sun is a typical star with a surface temperature of about 10,000 degrees Fahrenheit; many neighboring stars are equally hot, having the same kind of spectrum as the sun. There are, however, much hotter stars, some of the best examples being in the constellation of Orion. The three stars in the Belt of Orion, which nearly every one knows, and other stars nearby in the constellation have temperatures of 30,000 to 40,000 degrees; they are three times as hot as the sun. These stars are all blue-white in color, and their spectra have characteristic lines which can be recognized wherever found. Because of their high temperatures these so-called Orion stars are much more luminous than the sun; some of them shine with 1,000 to 1,500 times the sun's light, and as they can be seen far off they make convenient standards for estimating distances in space.

Our galaxy of a thousand million stars has often been likened in its shape to a watch, a biscuit or a bun. Imagining ourselves inside of the bun we see stars much farther in the direction of the Milky Way, toward the long diameter of the bun, than out where the bun is flat. The Milky Way extends around the sky and divides the apparent sphere into halves; hence we are in the middle of the bun, between the two slices if it were cut for a sandwich. The most powerful telescope has not yet reached the limit of the faint stars of the Milky Way, but we do see out at right angles to the main plane, and there beyond the stars in the foreground are to be found the other galaxies or nebulae like that of Andromeda. We would see some of these galaxies through the Milky Way were there not so many stars in the foreground.

Now if we consider only the hot and brilliant Orion stars, which we can identify by their spectra, we find that they are distributed all about us. The bright ones are in all directions, but the faint ones tend to follow the line of the Milky Way; the fainter they are the more they are concentrated in the middle band. In other words, the Orion stars outline the form of the flattened galaxy; we see no faint ones at right angles to the Milky Way because the system does not extend so far in that direction.

Next we notice the colors of the Orion stars; the brightest are white or blue-white, the fainter ones are yellow, and the very faint ones near the line of the Milky Way are red. Instead of calling the galaxy a bun we do better to call it a ham sandwich, and we are in the midst of the "ham." Between the stars of the middle layer there is mixed enough dust, so that at great distances through the ham all objects are reddened, but through a thin part of the ham the white stars are given only a slight tinge of yellow.

A few figures on the dimensions of this sandwich may be of interest. The long diameter is about 100,000 light years, while the thickness may be 10,000 light years. The absorbing layer or the ham is relatively quite thin—probably less than 500 light years thick. Roughly the ham may be a tenth as thick as each half of the bun.

The sun with the earth and other planets is not near the middle of the

galaxy, as astronomers thought up to about ten years ago; in fact we are about two thirds of the way out from the center toward one edge. The edge is marked for us not far from the bright stars of Orion. The stars in that part of the Milky Way, those that we see in winter, are not nearly as red as those of the summer Milky Way near the constellation of Sagittarius. From the motions of all kinds of stars it is known that the sun is revolving about a center in Sagittarius, requiring say 250,000,000 years to make the circuit, and it is just in the direction of the galactic center where we find the most interstellar dust, as shown by the reddening of the stars.

Probably some of the audience are interested in how the dust got between the stars in the first place. Is it material left over from the making of the stars, or did it come from eruptions or even blowing up of entire stars themselves? One good answer might be, why worry about the dust until you have found how the stars themselves came to be. It may be noted, however, that sufficiently fine particles of dust are repelled more by the light of a bright star than they are attracted by its gravitation. Once the dust is out in space there is little tendency for it to be collected by the stars.

The total absorption of the light coming to us through the thin part of the cosmic dust layer is about the same as the amount subtracted by the air, 20 per cent., or the absorption of a moderately clean piece of window glass. If you look edgewise through a piece of glass it does not take many feet of it to become quite opaque—and similarly for the edgewise view through the galactic layer of dust; we see a limited distance probably not as far as the galactic center. If you look out at night through a closed window and see the faint hazy speck of the Andromeda nebula, the light which is now affecting your eye traveled a million years with practically no loss, but during the past few hundred years a toll of 20 per cent. has been taken out by the dust in our galaxy; then another 20 per cent. by a few miles of air, and a last 20 per cent. by the window glass. You can get rid of this last third of the veil by going outdoors, and of about half of the effect of the air by climbing up on a mountain, but all the light from the nebula that will come in the next few hundred years is already enmeshed in the dust between the stars of our galaxy.

If you have ever been on a mountain or in an airplane, looking down on the lights of a city, you were perhaps conscious that very little of the life of a man-made community is marked by the lights at the street corners which shine up into the night. For every street light there may be dozen of homes each with its invisible fireside and all the human story that goes with it. So we may think of the stars at the corners of the cosmic streets as outlining the heavenly cities, and we wonder what is between those lights. We have not made many contacts with our celestial neighbors as yet, all we have done is to find a little dust between the stars.

FIVE THOUSAND YEARS OF ENGINEERING

By Dean R. H. FERNALD

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AVAILABLE records indicate that it was only some 5,000 years ago that man first put his ideas into definite form for future generations, using hieroglyphics that to-day we class as one form of writing. Through all these many centuries engineering science has had a profound influence upon the progressive develop-

ment of world civilization. More than five thousand years ago man had progressed sufficiently to make bricks for use with stone in the construction of great temples; to work to scale in making statues and monuments; and to change the entire course of the River Nile that the city of Memphis might be located at a specially desirable spot.

That there was no limit to the magnitude of the undertaking of the rulers of 3 to 5 thousand years ago is evidenced by underground tunnels thousands of feet in length, ventilated by many vertical shafts 6 to 9 feet in diameter; by huge stone temples with columns over 60 feet high and with single stones weighing over 1,500 tons; by canals for conveying merchandise from the inland cities of Egypt to the sea in trade with India, Persia, Greece and Rome.

As a general observation we should note that for the period from 5,000 to 500 years ago, great undertakings were accomplished through the use of hand tools, hordes of slaves and indefinite time, as contrasted with to-day with our refined machine tools, limited numbers of skilled operators and only days instead of years. For illustration, the great pyramid, built over 3,000 years ago, required 100,000 men 20 years for its construction, the huge stones being transported down the River Nile 100 or more miles by raft and a single canal 100 miles long consumed the period of the reign of several rulers before its completion.

During the thousand years preceding the birth of Christ, many great tunnels, sewers and aqueducts were built in Assyria, India, Egypt, Greece and Rome, the remains of which are familiar to many of you to-day. Two especially notable structures of this era were the Appian Way, a Roman road 350 miles long running in a straight course regardless of all obstacles, which was built 300 years B.C. and which was in practically perfect condition for over 800 years; and the Great Wall of China—the largest artificial construction in the world—1,400 miles long, 20 feet high and 15 feet wide at the top, made of stone and brick about 200 B.C. and still of exceptional interest to the traveler in China.

For the period from 500 to 100 years ago we note that, although Leif Ericson discovered America about 1,000 A.D., Columbus rediscovered us some 500 years later and made our continent known to the European world. About this same time the Spanish conquered the Aztecs and found extensive mining gallèries. Their tools were made of an alloy of copper and tin. They could carve the hardest metals and with the use of powdered silica could cut quartz, amethyst and even the emerald. Although iron was abundant in the vicinity, they apparently had no knowledge of its use.

Coming now to the time of our grandfathers—only one hundred years ago—we are amazed by the engineering achievements of their day, of which the following are typical illustrations: The construction of the Suez Canal, which required only ten years for its completion instead of the "reign of ten emperors"; Fulton's steamboat, which revolutionized river and coastwise traffic in this country; and the steam railroad, which was just born, but which by 1840 had several thousand miles under operation in the eastern part of the United States.

The general living conditions of our grandfathers' day were:

Light: Plenty of sunlight by day—no electric light, no gas light, not even kerosene lamps. Only open fires, tallow candles or sperm oil for illumination.

Heat: The fireplace and brick oven for warmth and cooking.

Food: In winter, dried fruits and vegetables,

whole wheat flour and corn meal, simple dairy products and frozen meat from the attic loft.

Clothing: Homemade, mostly from homespun cloth.

Transportation: The horse and sleigh or team and family carriage, perhaps only oxen lumbering along over rough roads with carts with no springs.

Amusements: What the local community could provide.

Hours of Labor: From ten minutes before sunrise to ten minutes after sunset, not the 8- or 6-hour day of 1934.

Accuracy of Work: Instead of measuring to the ten thousandth part of an inch, the degree of accuracy specified was "within the thickness of a worn shilling."

In the Gay Nineties: Imagine American citizens of average means, average tastes, average education, who never rode in an automobile; who never saw an airplane or a movie; who never enjoyed electric lights; who never heard a radio or who never traveled by express elevator to the top of a forty- or sixty-story building. Yet such was the typical citizen of only forty years ago when speed was typified by the bicycle.

To-day we seem to be speed mad. One hundred and twenty-five years ago, the first commercial steamboat did $5\frac{1}{2}$ miles an hour—now the *Mauretania,* the *Leviathan* and the *Savoia;* the 12-mile-an-hour first locomotive to run on rails in America has become the Burlington Zephyr at over 75 miles per hour; and the ill-fated Akron of the U. S. Navy, a Zeppelin type dirigible, was capable of "doing" 90 miles per hour.

The automobile of the nineties required over eleven hours to run a 55-mile race, and the War Department in purchasing cars stipulated that provision be made for attaching mules should the cars refuse to run. To-day our speed is limited only by restricting ordinances and laws.

Engineering and scientific research have brought us man-made silk, rivaling nature's product; solidified gas, which freezes ice cream so hard that we have to warm it before serving. We bounce around on tennis courts with shoes soled with sprayed rubber. We ride on air; we chat with friends on the other side of the world; transmit photographs across the ocean in a few minutes; send checks by radio; metalize paper; write with fountain pens made from sour milk and play poker with chips made from cheese. Due to science and engineering, we live in better homes; we eat better food; we reduce, through modern appliances, the labor of our daily living, and we have for our leisure hours the maximum of entertainment and relaxation.

Mr. Tripp and Mr. Kettering have pointed out that the condition of the common people remained practically stationary for all the thousands of years of recorded history until about 125 years ago. A citizen of Rome traveled to Britain just as quickly in 500 B. C. and by the same means as in 1800 A. D. For 5,000 years transportation was limited to 4 miles per hour or less.

Impassable miles made people prisoners to their own localities. The railroad, the ocean liner, the automobile, the movie, the radio and other modern devices are breaking down the barriers of provincialism and infinitely widening the horizon of the peoples of the world.

The dramatic changes of the past century may in large measure be traced to our greatly increased knowledge, appreciation and use of our vast natural resources of fuels, ores and minerals so essential to the production of power, to the construction of tall buildings, bridges and transportation highways and in the manufacture of all those modern appliances that the well-to-do millions of this country find indispensable in making our lives fuller and happier and which in so many ways make our normal living conditions and opportunities so

far superior to those of most other countries. No other country has been more lavishly blessed with such varied natural resources, and to their consistent development and use may be attributed the strategic position which we occupy among the great powers of the world.

The past 5,000 years have known many periods of depression, many devastating wars, many catastrophes, but after each a new era has been born and the world has come forth into the light of a better day and our brief review of 5,000 years of engineering clearly reveals era after era of progressive development. If from the cycles of the past, we can vision the future we must see before us years of unprecedented prosperity which will call for superior inventive genius, outstanding engineering capacity and aggressive directing foresight.

Our industrial and economic supremacy to-day is due in great measure to three major factors—the universal distribution of energy in the form of power; the development of almost human machines, and the science of management of men.

The future of this country depends largely upon our true accomplishment in the application of the sound principles of management and upon our grasp of the vital essentials affecting the conditions under which the great majority of men must live and work. The opportunity of the ages is before us. The stupendous problems which we are facing at this moment call for the keenest thought, the soundest judgment and unlimited initiative of serious, straight-thinking, scientifically trained men and women.

THE FIGHT AGAINST TERMITES

By C. A. KOFOID
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THINK over the items which entered into your noon meal and see how many of them came from the stored products of the plant world, such as sugar, starch and vegetable oil, and how few, if any, even of the proteins used, came from animals with the power to digest wood. Even the fabled Dutchman's horse, with his economical diet of sawdust, never grew fat on that diet. It is only the termites and a few other insects who have successfully solved the problem of making use of the celluloses as food. This dependence of termites on cellulose as food is the basic cause of the termite problem.

Man's ever-increasing use of lumber in the building industries provides killed wood which is more nutritious than naturally dead wood for termite food. In nature, wood-eating termites depend upon the fallen trees for their food supply. Man immensely increases the amount available, improves its quality, distributes it along his highways and accumulates it in his cities. Thus civilization, with its enlarging use of cellulose, ceaselessly tends to increase the food available for the wood-eating termites.

The domain of these termites is primarily in the tropics and warm-temperate zones. In the United States termites are wide-spread throughout the southern two thirds of the nation, with outlying extensions to the Canadian border.

The termite lives in the dark, apart from the rest of the insect world, and gives but little or no evidence of his presence in the wood. It is only when inter-

nal dry rot and decay have broken down the surface of the wood, or when the building has given way because of accumulating structural weaknesses or when the winged forms swarm, that the presence of the termite becomes manifest. However, in the case of the dry-wood termite, its presence is revealed by the pellets which are extruded from the burrows and gather in heaps on attic floors, or drop out of infested furniture upon the carpet.

Although the termite colony thus lives a secretive life, termites are constantly associated with other organisms of two distinct types on whose presence their very life depends. These are, first, the Protozoa within their digestive tract, which actually digest the wood chips which the termite has gnawed from the surface of its burrows. These microscopic animals extract from the wood some of its food values and make them available as sugars to the termite. Thus the termite itself eats but does not digest the wood. Every kind of wood-eating termite has its own peculiar and highly specialized fauna of Protozoa which distend its gut with a seething mass of these useful messmates.

The wood provides the carbohydrates or fuel for running the termite machine, but not the proteins necessary for growth. Where does the termite get these essential proteins? Undoubtedly he regularly gets a considerable part of the necessary food elements, the beefsteak of his diet, out of a second group of organisms, the fungi which habitually grow in the walls of every termite burrow, spreading there as microscopic, invisible threads. Some of these fungi are responsible for the subsequent decay of wood attacked by termites. Dry rot often follows termite attack. Each kind of wood-eating termite has many different kinds of fungi, including the common bread molds, growing in the wood of his burrows.

There are three major kinds of termites in the United States: the subterranean termites, which work in the soil and creep upward into dwellings; the dry-wood termites, which enter knotholes in trees, checks in poles and crevices in the superstructures of buildings and work down toward the soil; and the damp-wood termites, which favor logs, poles and wood buried in the soil. This third type is confined to the Pacific Coast. The subterranean termites range widely throughout the United States, and the dry-wood termites are confined to the southern states and the southwestern semi-arid region.

Termites live detached from a water supply, but they are delicately sensitive to the humidity of the air in their burrows. They regulate their ventilation and maintain a nearly saturated atmosphere. They habitually seek regions favored by moisture, though they can adapt their modes of life to desert conditions. The subterranean termite in the United States maintains connections with the moist ground, and from the soil enters the basement timbers of dwellings, wherever moisture favors the extension of his burrows.

The termite colony has three typical castes or kinds, with different structures and functions. These are (1) the reproductive pair, called king and queen, the parents of the entire colony; (2) the soldiers, with heavy jaws for fighting, but unfitted for feeding or excavating; and (3) the young or nymphs, which in some kinds of termites are supplemented by a worker caste. The young and workers are doomed to do the drudgery of digging, feeding the soldiers, baby tending, the building of tunnels and towers and keeping the burrows clean and in order. Thus in certain kinds of termites child labor prevails and in others a large slave caste is developed. In all termites an annual crop of winged forms is sent forth from the colony like

propagandists to extend the species into new locations. A brief flight of these alates is followed by pairing and settlement, and digging into the earth or wood to establish a new home. For the whole of the first year the growth of the new colony is very slow. Less than a dozen members are present by the end of that year. The first child born is always a young soldier who is enlisted in military service when half grown.

Elaborate social instincts control the life of this diversified colony. King and queen are fed and groomed by the workers or nymphs, who also tend the young in the early stages; the soldiers kill invading ants and foreigners from other colonies, even of the same species. Upon the workers or young falls all the hard labor of the ordered life of the colony.

The development of a military caste, the exploitation of the young, the limitation and control of the reproductive function, and the substitution of the interests of the colony for the interests of the individual, are all characteristic of the ordered social life of the termites. There are many interesting parallels between the various types of social organization in termite colonies and the efforts at organization in the human hive. In both alike, organization develops at the expense of the freedom of the individual and operates in the interest of the group as a whole. The termite colony is successful because of this organization, but the body of the termite stands very low among insects in structural evolution of the individual.

A termite colony once established is potentially immortal. It can live and extend its burrows as long as it can maintain access to wood. Exploratory tunnels are driven to find new sources of food, and detached outlying groups develop supplementary reproductives and progressively become new colonies on the fringes of the parent group. The subterranean termite in the United States builds covered burrows of a dirt plaster over cement walls, and even up to the second story in buildings. It finds its way through these tunnels to bookshelves, documents in storage and parts of the building remote from one another. Termites select particular pieces of wood in which fungi grow luxuriantly, and reject others, except for mere avenues of transit. You may have heard of the lazy boy in South Africa who left his trousers on the floor, and in the morning found only 10 buttons and a buckle. The termites had devoured the cotton garment.

The death of a king or queen is quickly made good by the development of a supplementary king or queen. But so long as a primary or even a supplementary king or queen in full reproductive function is present in the colony, the development of any additional kings and queens from the full-grown young is inhibited by the secretions of the existing king or queen transmitted to the adolescent young by the grooming habit. The young acquire sexual maturity only after swarming from the parent colony. Thus termites exercise birth control.

This menace of the termite has been the subject of research by a committee representing both science and industry formed at the University of California. The results of this investigation have been published by the University of California Press in a book, "Termites and Termite Control," the second edition of which is now appearing. The proceeds of the sale of this volume are to be used for further research on termites. This book tells how each of the particular kinds of termite must be fought in a way suitable to its habits and its depredations.

The subterranean termite is by habit attached to the ground. A dwelling protected against it should be elevated on concrete or other foundations. Termites burrow through lime mortar, but

not through cement mortar. Foundations should extend at least a foot above the ground, to provide against the termites building tunnels over the cement to reach the wood above. All waste wood should be removed from under and around a dwelling. This includes the lumber in concrete forms, stumps, roots and builders' rubbish. In termite-infested territory chemically treated wood, especially pressure-treated creosoted lumber, should be used as a preventive, or naturally resistant wood with a high extractive may also be used, especially in the basement structures and subfloor. In the case of the dry-wood termite prevention is much more difficult, because of the fact that the winged pairs tend to creep into crevices around openings in the house, under shingles and tile and into cracks or checks in lumber. Thorough painting and the screening of all openings assist in prevention of infestations. Chemically treated wood meets this menace more effectively.

Investigations have shown that all three kinds of termites are generally associated with certain fungi which have the uncanny faculty of utilizing arsenic in feeding, without being killed, in such a way that the highly volatile and very poisonous arsine gas is liberated from arsenic used in treating the soil or in chemically treating wood and wall board as a termite preventive. The Termite Investigations Committee is therefore strongly recommending against the use of arsenic in any form whatever in building materials, wall boards or under and around dwellings as a termite preventive. The reason for the recommendation is the arsenic hazard in fires and the potential danger of the production, by fungi introduced by termites, of the toxic arsine and the slow increase of arsenic in the human body to a toxic or lethal dose by continued inhalation of the arsine.

This fight against the termite is only one phase of the broader problem of man's ceaseless battle with the insect world for the use of the products of the plant world. This contest with the termite will tend to increase with man's ever-widening use of cellulose and the extension of his civilization into the tropics.

SHARK ATTACKS ALONG THE SOUTH CAROLINA COAST

By E. MILBY BURTON
DIRECTOR, THE CHARLESTON MUSEUM

AUTHENTIC published records of persons having been bitten by sharks while in bathing along the Atlantic coast north of Florida are rare; indeed, after exhaustive research, I have found no authentic record excepting an episode off New Jersey in 1916.

Yet, within the last decade, off the coast of South Carolina there have been several well-authenticated cases of fierce attacks upon bathers. I am setting down here some authentic, and what I shall call semi-authentic records of attacks which have occurred off the South Carolina coast in recent years.

On June 21, 1933, 15-year-old Drayton Hastie, of Charleston, S. C., was bathing at the north end of Morris Island, which is situated at the mouth of Charleston Harbor. I am giving an account of the incident in Mr. Hastie's own words:

> . . . Far up the shore line I saw what I thought might be the dorsal fin of a large shark cutting the rough surface. I stood up and strained my eyes to make certain. Yes, it must be a fin, I concluded. . . . Reaching the place and finding nothing that resembled a fin, I believed that I had mistaken a choppy wave for a fin. . . . I did not like the idea of swimming with sharks all around, so I sat down in about three feet of water, at which place the beach sloped gradually until about six feet beyond where I was sitting, at the point it made a deep drop. I was almost certain that in such shallow water I would be safe from anything large enough to bite.
>
> . . . I felt a swerve of water, which was immediately followed by an impact which brought me to my senses. Something clamped down on my right leg. I was aware of a tearing pain up and down my leg, and that I was being pulled outward by something which seemed to have the power of a horse. Looking down, I saw, amid the foam and splashing, the head of a large shark with my knee in its mouth, shaking it as a puppy would shake a stick in attempting to take it away from some one. Through natural instinct, I started kicking frantically with my unharmed leg in order to free myself. I freed my right leg, only to have the monster bite me on my left one. All this time I had been pulling myself up on the beach backwards with my hands and kicking at the rough head of the shark, which seemed to me as solid as Gibraltar.
>
> . . . Although to you this may seem long and strung out, it must have all happened in a space of ten seconds.
>
> . . . Although some people said I had been bitten by everything from crabs up to whales, I still have a perfect design of a shark's mouth around my knee, measuring ten inches across. This confirms the statement of my friend who was standing on the bank and who said that the shark was easily eight feet long.

Mr. Hastie, with much difficulty, was carried to the army hospital at Fort Moultrie, where first aid was administered. It required more than 30 stitches to close the numerous wounds. Later he was transferred to Riverside Infirmary, in Charleston, where he remained a patient for two weeks.

Both the week before and the week after the attack on Mr. Hastie, two eight-foot sharks were taken within one hundred yards from where he had bathed. On identification they were found to be the yellow or cub shark (*Hypoprion brevirostris*), thought to be more a native of the West Indies than of the Atlantic Coast. The only previous record of this shark off Charleston was one small one taken in May, 1882, by Jordan and Gilbert,[1] and another small

[1] *Proc. U. S. Nat. Mus.*, Vol. V, p. 581, 1882.

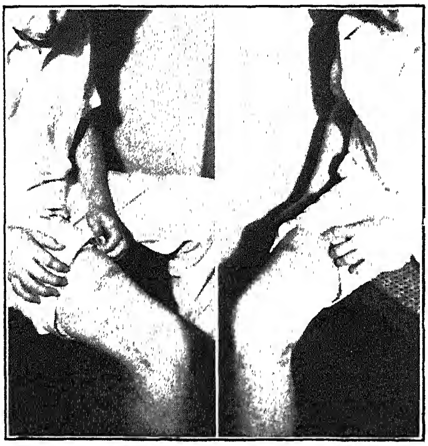


Fig. 1. Photographs of right leg of Drayton Hastie, who was bitten by a shark while swimming off Comings Point, Morris Island, June, 1933. Photograph taken by Wesley Jackson, June 25, 1934.

one taken by a member of the Charleston Museum staff in October, 1932.

Mr. Lewis Kornahrens was attacked while in the surf at Folly Island on July 31, 1924. Unfortunately, he is no longer in the city and I can get no statement from him. I am quoting from the chart of the Roper Hospital, where he was admitted the day the attack occurred:

> The patient says he was standing in the breakers near the sea-shore in water about waist deep. This was at Folly Beach near the Elks Club. He says something that he thinks was a fish grabbed on both legs at the same time and that he hit the fish (?) with his fist, whereupon it turned him loose. A Negro man came to his assistance and helped him to shore. The patient says the Negro saw about six feet of the fish but didn't stop to observe closely (signed) Dr. J. N. Walsh.

Mr. Kornahrens was treated for "repair of lacerated muscles on the left knee and leg," which required more than 100 stitches, and was discharged on August 28, 1924. Mr. Kornahrens continued to feel a severe pain in his knee cap and it grew steadily worse. Finally he was readmitted to the hospital on November 4, 1924. A minor operation was performed and a fragment of a tooth was taken from the vicinity of the knee cap. His attending physician was Dr. D. L. Maguire, of Charleston. This fragment of tooth is now in the possession of the Charleston Museum (*Spec. 2811*). Recently it was sent on for identification to Drs. Gudger and Nichols of the American Museum of Natural History of New York, and the following is quoted from a letter from Dr. Gudger, dated July 13, 1933:

> I am returning under separate cover today the tooth fragment you sent. This is not a barracuda tooth. There is no doubt on this point. Mr. Nichols and I are both satisfied that it is a fragment of a shark's tooth, and we are inclined to think that it is from one of the mackerel sharks, but presumably a young specimen.

Young Kenneth Layton and a friend were in bathing at Pawley's Island, which is about seventy-five miles north of Charleston, when they were startled by a cry of "Shark! Shark!" from a man standing on the beach.

At the place where they were bathing, the beach is very flat; consequently, they were well out from shore, although in water not much over four feet. Both he and his friend were terribly startled when they heard the cry of warning. Looking down the beach, they saw a large dorsal fin of a shark 50 yards away. They immediately rushed for shore. Layton says the shark deliberately tried to cut them off. When they reached water about waist deep, Layton was seized by the right heel and ankle. He struggled frantically, and in the meanwhile his friends who were bathing nearby were rushing to his assistance. Together with his struggle and the commotion caused by the approach of his friends, the shark was frightened to such an extent that it relinquished its hold.

Young Layton was rushed to the

Riverside Infirmary at Charleston, where it was ascertained that several tendons in his leg, including the Achilles, had been severed. His attending physician was Dr. A. Johnston Buist, of Charleston, S. C., who states that the patient has completely recovered the use of his foot. This attack occurred on August 28, 1933. The information regarding the attack was furnished me by Layton himself.

Mr. C. B. Hernandez tells me that in July, 1907 or '08, while swimming in a small creek about 15 feet deep, back of Coles Island, he was suddenly attacked by a shark. At the time, he was floating on his back. When the shark grabbed hold of his left knee, it apparently did not get a firm grip, but immediately attacked him again, getting a much firmer hold on the lower part of his leg. Mr. Hernandez says hardly a second elapsed between the first and second attack. He immediately floundered over and fought off the shark, which he saw quite clearly at the time. Apparently the shark was frightened away, because, though bleeding freely, he was not molested again as he swam back to the dock. Mr. Charles Millikan was standing at the head of the wharf when the attack occurred and clearly saw the shark. Both he and Mr. Fernandez estimated it to be about five feet in length. The scars on Mr. Hernandez' left leg are in crescentic form.

Mr. W. E. Davis, while swimming in James Island Sound, was viciously attacked by a shark. Mr. Davis is a member of the Officers Reserve Corps, and has recently been called into active service and is stationed at one of the C. C. C. Camps at White Springs, Florida. I have received a letter from him and am quoting from it in part:

> On this particular afternoon, the tide was extremely high, even for a spring tide. So high, in fact, that it lacked less than an inch of covering the bridge. It was a perfectly calm afternoon with barely a ripple on the water. Following my custom I dove from the wharf and headed out into the sound. I had swam probably thirty yards when my left foot was seized. Due to the water I was conscious of no pain, only pressure. My instant and involuntary reaction was to jerk practically clear of the water, and due to the sharpness of the teeth holding me I succeeded in ripping my foot clear. I immediately turned around and headed for the bridge. As I did so I saw directly in front a swirling of the water and at the same time the white of a shark's stomach and the tip of its tail. Unthinkingly, in my haste to regain the wharf, I swam directly over this spot and in so doing experienced a sharp burning contact with some rough-skinned body. Fortunately I reached the wharf very shortly. I was pretty well knocked out but did notice that my foot was practically mangled from about five inches up the leg down. Also a raw spot where the rough skin had touched me. The lacerations on my foot continued out in cleanly defined cuts to the tips of my toes, indicating that the shark had really held on to the last.
>
> . . . It must have been a vicious fish and an intentional attack because I had no warning whatsoever. Further, the water that afternoon was exceptionally clear so that the shark could not have been mistaken as to what it was attacking. Also I was swimming vigorously and making quite a commotion in the water. Under the conditions I think it was a hungry, vicious shark that intentionally attacked me, and had

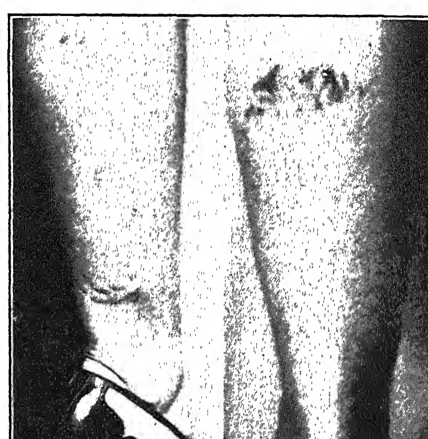


Fig. 2. Photographs showing right leg of Miss Emma G. Megginson who was bitten by a shark(?) while swimming off Folly Island, June 16, 1933.

I been further out in the sound would have attacked me again.

When Mr. Davis was taken to the St. Francis Xavier Hospital in Charleston, it was at first thought that his foot would have to be amputated. Fortunately, this did not have to be done, and Mr. Davis regained the full use of it, although it required 70 odd stitches to close the lacerations. His attending physician was Dr. Robert Cathcart, of Charleston. This attack occurred on May 29, 1919.

These five cases, I feel, are absolutely authentic. The succeeding cases which I shall outline come under the category of semi-authentic, as no one actually *saw* the shark.

Mrs. Walter K. Kahrs and her husband were bathing at Folly Island on August 2, 1925. They had waded out until the water was about waist deep, Mrs. Kahrs in advance of her husband. They had both dived through the first line of breakers and were swimming steadily outwards, when Mrs. Kahrs was suddenly attacked. She screamed frantically and fought off the shark (?). Meanwhile, her husband, who had been swimming about ten feet behind her, rushed to her aid. Between the commotion of both of them the shark (?) was scared away.

Mrs. Kahrs was rushed to the Riverside Infirmary at Charleston, where it was found she suffered "multiple lacerations on both thighs, right buttock and hip." It required 78 stitches to close the numerous cuts and gashes. Her attending physician was Dr. John LaRoche, of Charleston.

Mrs. Kahrs tells me she was so frightened that she has no clear conception of what really happened. She was simply conscious of a sudden attack by some very large object. She thinks she struck the fish in her struggle, but is not perfectly certain about it. She also tells me some of her scars are in the shape of a half-moon.

Miss Emma G. Megginson was standing in the surf in water about waist deep, when she felt something pinch the calf of her left leg, but thought it was her younger brother playfully grabbing at her. In another moment she felt a much more savage attack and then saw blood come to the surface of the water. She rushed out of the surf, and found she was bleeding freely from numerous cuts. She was taken to the Roper Hospital at Charleston, where it required 36 stitches to close the wounds.

Miss Megginson tells me she saw what was apparently the back of the fish and estimates it as being about a foot wide and black. She very kindly consented to let me have a photograph taken of her scars. The attack occurred at Folly Island on June 16, 1933. Her attending physician was Dr. G. F. Heidt.

I have endeavored to track down rumors of several other attacks that have been reported from time to time. But invariably they either happened many years ago, the victim and witnesses are dead or have moved away or a person has drowned under unusual circumstances. The information has been so meager in all the cases that I feel that it can not even be placed in a semi-authentic classification.

Invariably when an attack of this kind occurs every one immediately concludes, "barracuda." In many respects this is quite understandable, as the psychological effect would be extremely bad and no one would frequent the bathing beaches. In fact, last summer immediately after the attacks on Miss Megginson and Mr. Hastie, there was a marked decrease for quite a time in the number of bathers. The great barracuda (*Sphyreana barracuda*) is apparently very rare in and around Charleston. There is a skull of a fairly large specimen in the Charleston Museum, labeled

"off Charleston Harbor, 1874." That appears to be the only authentic record. Occasionally the small northern species (*Sphyraena borealis*) is caught, but that, too, is apparently quite rare. For the last five years the museum has been trying to secure a specimen for its collection, but has been unsuccessful so far.

For any one wishing further information on these various cases, I will be only too glad to make appointments for them with the following: Messrs. Hastie, Layton, Hernandez, Mrs. Kahrs and Miss Megginson, Drs. Buist, LaRoche, Cathcart, Heidt and Maguire; and I feel sure, for any one sufficiently interested, I can get permission from the hospital authorities for him to go over the charts and records of the various cases.

There are records of the following sharks[2] having been taken in and around Charleston:

NURSE SHARK (*Ginglymostoma cirratum*). Occasionally taken during the warmer months.

DOG-FISH (*Mustelus canis*). Two records, one seen by Jordan and Gilbert in 1882 (Proc. U. S. Nat. Mus. 1882, Vol. V, p. 581), and the second one brought in last winter by a trawler.

TIGER SHARK (*Galeocerdo tigrinus*). A 42-inch specimen brought in during December, 1932. Taken by a fisherman about twelve miles off shore. This shark was totally unknown to the fishermen and longshoremen, showing that it must be extremely rare. This is the first authentic record of its ever having been taken off the South Carolina coast.

SHARP-NOSED SHARK (*Scoliodon terrae-novae*). The most abundant of our sharks and the bane of the fishermen. Never seem to reach a large size.

GROUND SHARK (*Carcharhinus commersonii*). Moderately abundant during the warmer months.

BLACK-FIN SHARK (*Carcharhinus limbatus*). Extremely abundant during the warmer months. Apparently follows the shrimp trawlers in large schools. I know of a case where as many as nineteen were taken from under a trawler in a comparatively short space of time. Very few specimens exceed five feet in length.

YELLOW or CUB SHARK (*Hypoprion brevirostris*). Only four authentic records, but possibly more common than generally thought.

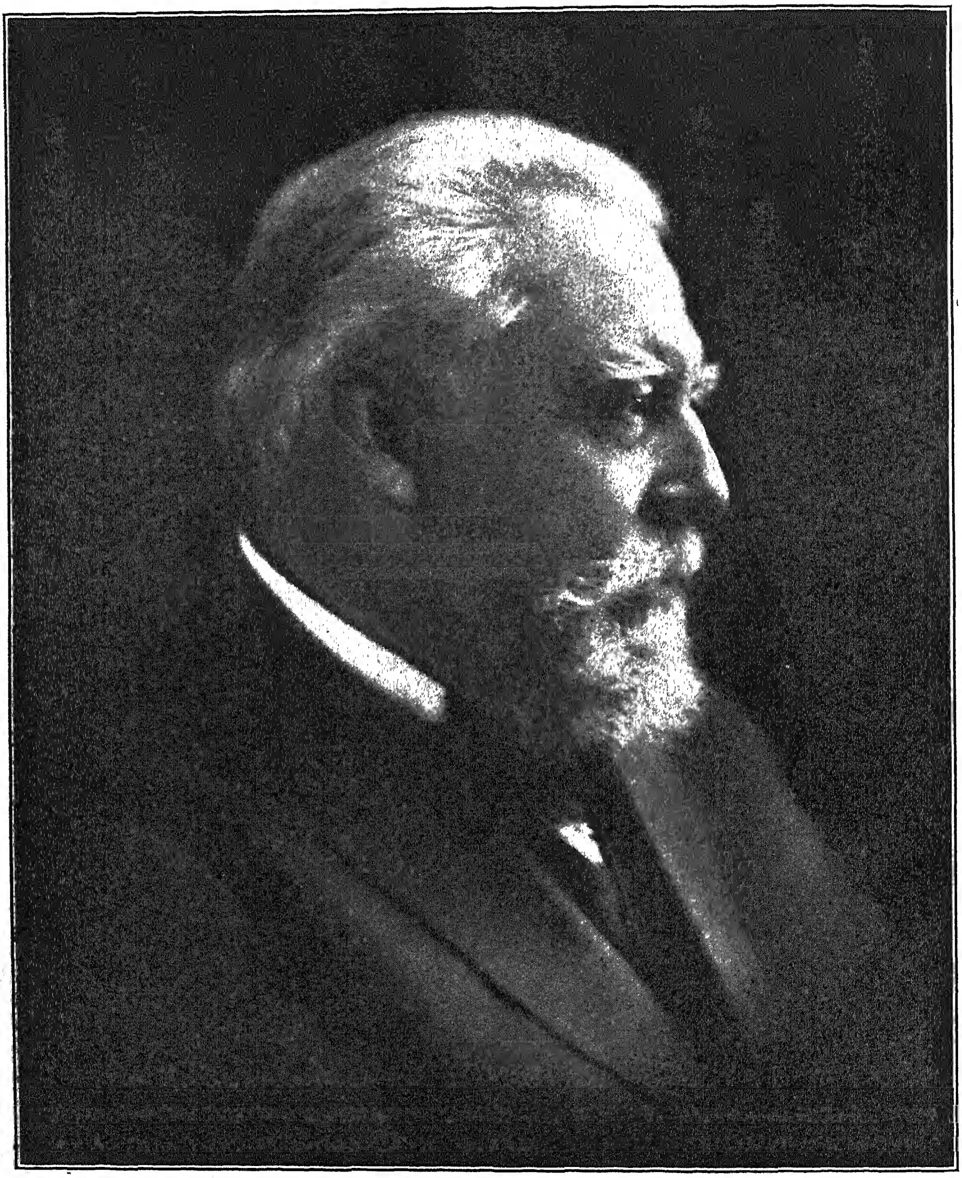
SHOVEL-NOSED SHARK (*Sphyrna tiburo*). Common during the warmer months.

HAMMER-HEAD SHARK (*Sphyrna zygaena*). This is also a moderately common species during the summer months.

SAND SHARK (*Carcharias littoralis*). One of the most common of our large sharks. Capt. William Magwood, of the shrimp trawler *Geneva Moore*, caught six, ranging in length from 8½ feet to 9½ feet, in a single haul of the net. Large specimens are frequently brought in by the trawlers during the summer months.

MACKEREL SHARK (*Isurus punctatus*). The only authentic record is a drawing made by Dr. Edmund Ravenel in 1821 from one brought in from off shore. The identification was made by Henry W. Fowler, of the Academy of Natural Sciences of Philadelphia. It is interesting to note that Dr. Ravenel was a close friend of the celebrated ichthyologist, Dr. John Edward Holbrook.

[2] Am using the word shark in the generally accepted sense of the word, and am not dividing them into various families.



THOMAS HUSTON MACBRIDE

THE PROGRESS OF SCIENCE

THOMAS HUSTON MACBRIDE, AN APPRECIATION

In his gradual development from a field naturalist, interested in many different phases of natural science, to a specialist in a limited field, Thomas H. Macbride illustrates in his life the tendencies of science during the more than six decades of his scientific activity. Born in eastern Tennessee, the oldest son of a Presbyterian minister, he was brought to Iowa in a wagon at the age of six, his father's ardent advocacy of the abolition of slavery having made it desirable for the family to find a home in free territory. Educated at Lenox and Monmouth colleges, after his graduation he was for eight years an instructor in mathematics and modern languages in the former institution, and at the same time an ardent amateur naturalist. His introduction to natural science was through Samuel Calvin, one of his early teachers at Lenox, and the association there begun continued without interruption until the latter's death in 1911. In 1874 Calvin was called to the University of Iowa as professor of natural philosophy, and when, four years later, he found the multitudinous duties of such a chair growing beyond his capacity to handle them alone, he secured Macbride as his coworker, as assistant professor of natural science. As such, he taught botany, geology and zoology. Then, when geology became a separate department, Macbride was made professor of botany and systematic zoology, and finally, in 1889, professor of botany. Shortly thereafter he went abroad, spending six months in Strasburger's laboratory at Bonn. Upon his return, he was one of the first to introduce to American students the new methods and view-points there developed. In 1914 he was elected president of the university, but found administrative work little to his taste and in 1916 he retired, to devote himself to his special studies and to answer the many calls made upon him as the first citizen of Iowa. In his last years he spent much of his time in Seattle, and there he died on March 27, 1934.

His scholastic career is paralleled by his publications. His first paper seems to have been zoological and many of his earlier writings were in the field of geology; in fact, he retained an active interest in geology long after his teaching of the subject had ceased. He was the author of several reports on the geology of Iowa counties, the last of which appeared in 1905, and a paper on paleobotany was issued in 1907. But botanical topics occupied his attention increasingly. At first general, these became more and more specialized, first in the fungi, and then in the more restricted field of the slime molds, upon which group he became recognized as the leading American authority.

In his early days he was greatly influenced by his field trips, often taken in company with Dr. Calvin, and when he came to the university, these trips were continued, especially in the summer, when it was possible to go farther afield. On one such trip to the Black Hills, he and Calvin discovered the remarkable fossil cycads of that region, and with much labor and considerable expense, brought a number of fine specimens to the university, where they still remain. Later, he visited the Yosemite, New Mexico, Southern California and Washington, and his collections of slime molds from these regions constitute an important part of the Myxomycete collection at the university, largely built up by his efforts and unexcelled in the western hemisphere.

He had an unusual capacity for arousing the interest and affection of his students and for imparting to them something of his own enthusiasm for nature. But his interests went far beyond the

classroom. He was one of the earliest advocates of conservation. A paper urging the establishment of parks in each county appeared in 1895, and in 1901 he was the first president of the Iowa Park and Forestry Association. One outcome of this interest in the preservation of natural conditions and in the study of plants and animals in their native surroundings was the establishment of the Iowa Lakeside Laboratory in 1909. His work for conservation is fittingly commemorated in the name of the Lake Macbride State Park, recently established near Iowa City.

He never sought honors, but when they came to him in the natural course of events, he accepted them and such responsibilities as they entailed with modesty and cheerfulness. In 1897 he was made president of the Iowa Academy; in 1903 he was vice-president and chairman of Section G of the American Association; he was the holder of several honorary degrees. More important than these, however, is the tradition of industry, wide scholarship, kindliness and courtesy which he has bequeathed to his successors in the department he founded and to the university and commonwealth he served. Such traditions accumulate slowly, for the men who can establish them are rare, but for all their intangible nature, they come to be recognized as the most precious heritage any university may possess.

G. W. Martin

Department of Botany
University of Iowa

PROFESSOR EDWARD BARTOW, PRESIDENT-ELECT OF THE AMERICAN CHEMICAL SOCIETY

Professor Edward Bartow has had the career of an unusually successful professor and head of a department of chemistry in the Middle West. Next year he will become the president of the American Chemical Society, which has 17,000 members and an annual budget of $440,000.

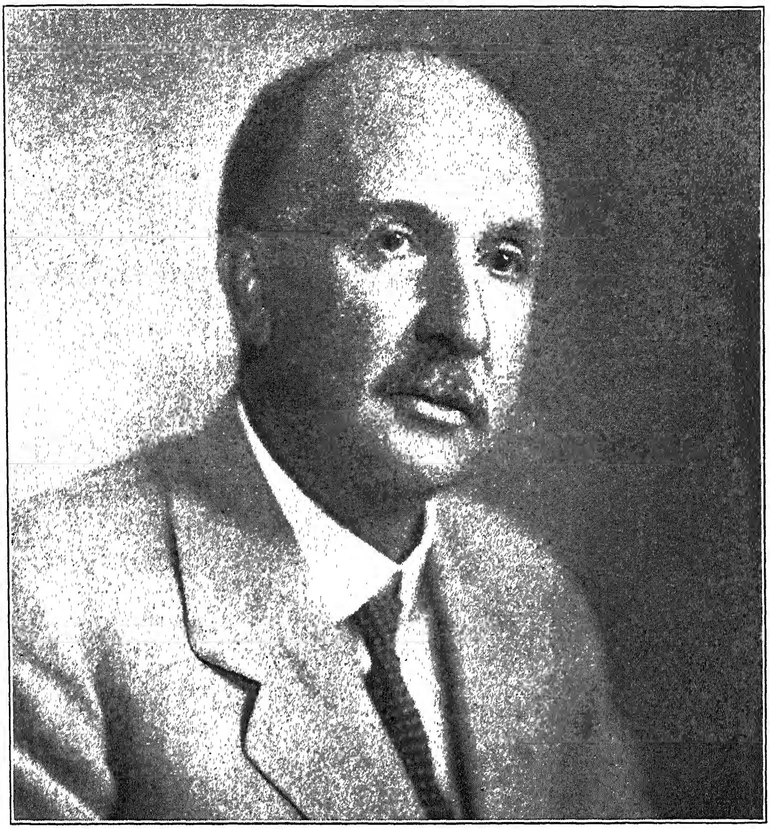
Professor Bartow was born in 1870 in a small village near Fishkill, New York, and prepared for college in a private academy at Fishkill. He graduated at Williams College in 1892 and took his doctor's degree at Göttingen in 1895. After two years as an instructor in Williams College he spent eight years at the University of Kansas and was then called to the University of Illinois as director of the State Water Survey, which had been founded by Professor A. W. Palmer. He was at the same time associate professor for a year and then professor of sanitary chemistry.

Many men who received their training under him from 1905 to 1917, eighty or more officers who worked under his direction in France and many who have graduated from the State University of Iowa are now scattered over the country in responsible positions, as professors, directors of water works laboratories, chemists caring for the wastes of industrial plants and in other occupations farther afield from their special training. It is in no small measure the splendid loyalty of these men which has led to his selection as president-elect of the American Chemical Society—the greatest honor in the gift of American chemists.

During his first years as director of the Illiniois State Water Survey, the first organization of its kind in the Mid-West, he was a leader in the campaign to combat epidemics of typhoid fever by the introduction of pure municipal water supplies.

In 1914, while in England, he became acquainted with the recently discovered activated sludge process for the treatment of sewage. After returning to Urbana he spent several years in studying and developing this process. He secured its introduction in Milwaukee and it is now used in Chicago, Indianapolis and in many other cities.

When air in small bubbles is passed



PROFESSOR EDWARD BARTOW

through raw sewage for from one to three weeks, aerobic bacteria slowly increase and an activated sludge will settle out on standing for a short time, leaving clear water from which 90 per cent. of the organic matter has been removed and which can be discharged into a river or lake without offensive pollution of the water. With "activated sludge" produced in this way new portions of sewage may be purified in from six to twelve hours. As the apparatus is less expensive and requires only 10 per cent. of the area needed for trickling filters, the only other method then in practical use on a large scale, the economic saving due to the method is enormous.

In 1917, soon after the United States entered the war, Professor Bartow was commissioned as major in the army and went to France to care for sanitary work and especially for water supplies for our expeditionary forces. Later he was commissioned lieutenant-colonel. With a large staff of able assistants he not only directed sanitary work for men in the field but also rendered notable service by calling the attention of European chemists to the use of liquid chlorine in purifying water supplies.

While in France his delightful personal qualities secured for him a host of French, English and American friends and it is doubtful if any other American chemist has such a broad and worthwhile acquaintance.

Soon after his return from France Professor Bartow was appointed head of the department of chemistry and chemical engineering at the State University of Iowa. Since he went there the department has had a rapid growth, espe-

cially in the field of graduate work, and a very fine new chemical laboratory has been built.

Professor Bartow has received many honors. He was awarded the *Medaille d' Honneur* by the French Government, and at Madrid last summer he was chosen vice-president of the International Union for the United States and made a corresponding member of the Spanish Academy of Sciences. He was given the honorary degree of D.Sc. by Williams College in 1923.

W. A. Noyes

Emeritus Director
The Chemical Laboratory
University of Illinois

AWARD OF THE PERKIN MEDAL TO DR. GEORGE O. CURME, JR.

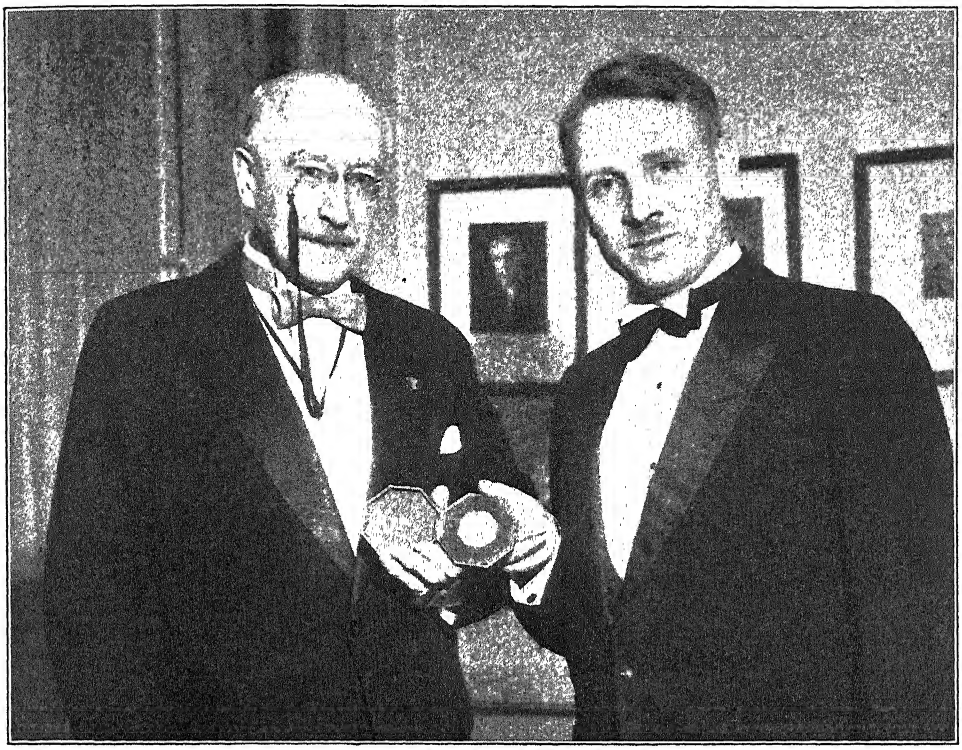
On the evening of Saturday, October 6, 1906, a banquet at Delmonico's, New York, with Sir William Henry Perkin as the guest of honor, brought to a fitting close the American celebration of the Perkin Jubilee, for it was in the Easter vacation of 1856 that Perkin's discovery of the "mauve dye" laid the foundation for what rapidly grew into the vast coal tar dye industry.

In commemoration of the occasion, a Perkin Medal was established, to be "awarded annually for the most valuable work in applied chemistry," and the first medal was presented to Sir William himself.

To an American industrial chemist, no higher distinction can come than the award of this medal, for the jury of award is made up of representatives of the American Chemical Society, the Electrochemical Society and the American Institute of Chemical Engineers, as well as the American Sections of the Society of Chemical Industry and of the Société de chimie industrielle, and the list of medalists is indeed a roll of honor comprising those who have been great builders of American chemical industry.

The jury selected Dr. George O. Curme, Jr., for the 1935 award because he too has been a founder of a new and rapidly expanding industry, namely, that of synthetic aliphatic organic chemistry based upon petroleum as initial material, and it is entirely possible that the development of this new petroleum chemistry during the next fifty years may rival or even excel that of the past fifty in coal tar chemistry. In fact, the successful commercial synthesis of ordinary ethyl alcohol seems as noteworthy

THE FIRST PERKIN MEDAL
Which was awarded to Sir William Henry Perkin for his discovery of the "mauve dye" in 1906.



THE AWARD OF THE PERKIN MEDAL
PROFESSOR MARSTON T. BOGERT, OF COLUMBIA UNIVERSITY, PAST-PRESIDENT OF THE SOCIETY OF CHEMICAL INDUSTRY, PRESENTING THE MEDAL TO DR. GEORGE O. CURME, JR.

an industrial accomplishment in this field as that of synthetic indigo was in the dye field.

For decades coal tar was used only as roofing material, for road building, briquetting coal dust, and the like, before it was discovered that by distillation it could be made to yield a great variety of useful products, from which in turn new industries rapidly grew. This history is being repeated in the case of petroleum. At first used mainly for lubricants and illuminants, it was soon found that even for these uses its value could be greatly enhanced by suitable heat treatment. But these processes were chiefly engineering problems, and the industry exhibited little or no interest in what the synthetic organic chemist might contribute.

It was Dr. Curme who, some twenty years ago, recognized this situation clearly and envisioned its possibilities. Starting with simple hydrocarbons obtained by the "cracking" of petroleum fractions, he has demonstrated how there can be prepared therefrom, on a commercially profitable basis, in part by wholly novel processes, such interesting compounds as ethylene chloride, ethylene glycol, ethylene chlorohydrin, ethylene oxide, dichloroethyl ether, various alcohols, aldehydes and ketones, acetic acid and its derivatives, and such new products as carbitol, butyl carbitol, methyl and butyl cellosolves, pyrofax, vinylite resins, and many others.

Prior to the world war, we were recognized leaders in the manufacture of inorganic and "heavy chemicals," but were dependent upon Europe for most of our organic chemicals, and this deficiency crippled us severely during that conflict. Since then we have succeeded in building up some of our organic chemical industries, like the dye industry, for ex-

ample; but it has remained for Dr. Curme and his associates to bring to us the leadership in that vast and far-flung domain of synthetic aliphatic chemistry based upon a raw material, petroleum, with which we are so richly endowed.

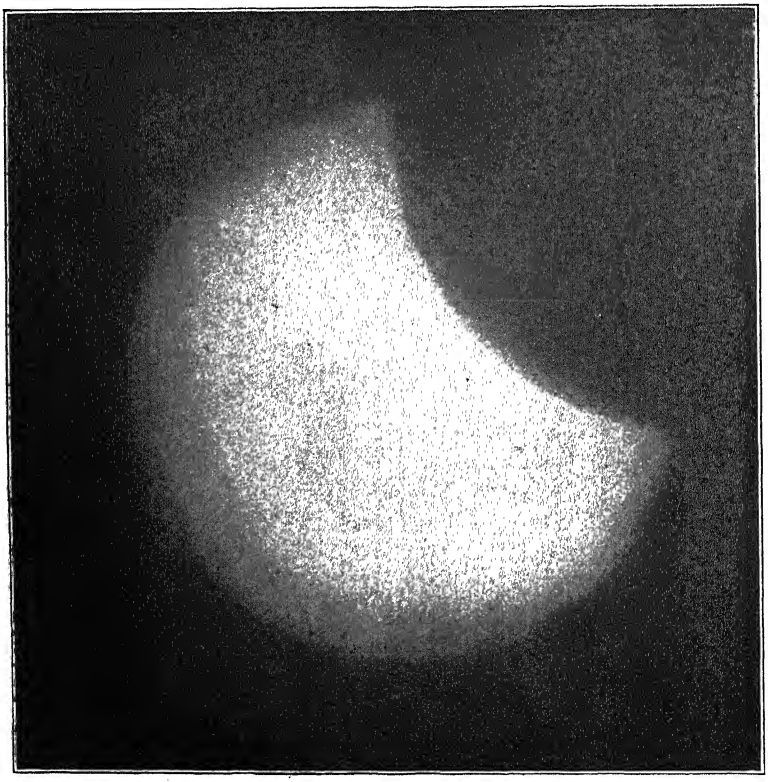
Curme's work has had a stimulating effect also upon university departments of chemistry and has increased the demand for competent and well-trained synthetic organic chemists. In war, as well as in peace, an adequate supply of such experts is of immense importance, as they know particularly well who have had experience in the Chemical Warfare Service or the Ordnance Department.

Dr. Curme is vice-president and director of research of the Carbide and Carbon Chemicals Corporation, and in 1932 received the Chandler Medal of Columbia University, which is awarded annually "to the chemist whose research work, in its commercial application, has done most to advance industry."

MARSTON TAYLOR BOGERT
PROFESSOR OF ORGANIC CHEMISTRY
COLUMBIA UNIVERSITY

THE FEBRUARY SOLAR ECLIPSE

SWEEPING over North America with its usual astronomical precision, the moon's penumbra raced across a large part of this country on February 3, partly dimming the light of day. In New York two fifths of the sun was obscured at 11:31 A.M. However, the greater part of the land suffered from being covered with heavy clouds, so that relatively few observers were favored with a view,



THE SOLAR ECLIPSE OF FEBRUARY 3
A PHOTOGRAPH TAKEN AT THE HARVARD OBSERVATORY AT 11:15 A. M.
(EASTERN STANDARD TIME).

—*Courtesy of The American Museum of Natural History*

DIAGRAM OF THE APPROXIMATE EXTENT OF THE PENUMBRA

FALLING ON NORTH AMERICA AT 11:00 A. M. (EASTERN STANDARD TIME), ON FEBRUARY 3. THE SHADOW AREA WAS MOVING NORTHEAST AT THE RATE OF ABOUT 1,600 MILES PER HOUR WITH THE AXIS TURNING IN A CLOCKWISE DIRECTION. AT THE BEGINNING AND END OF THE ECLIPSE THE SHADOW WAS MUCH SMALLER THAN SHOWN HERE.

although seemingly there was a high degree of popular interest in the event. (One of the largest cities where success was attained was St. Louis, Mo.) As if to make up for the disappointment, the moon on the evening of the following day shone above the clear horizon just after sunset as an exceedingly thin crescent, with the *earthshine* lighting up the entire dark side of the moon, and alongside, forming a straight line with it, were Mercury and Venus, the three celestial objects offering a magnificent sight.

Astronomically these partial eclipses of the sun are quite unimportant, for almost none of the features take place that occur with total eclipses. Probably the most valuable observations to make at partial eclipse times involve getting the "contacts" or exact instants of beginning and ending. The timing furnishes a check to part of the refined computations necessary in this type of work. Sometimes an eclipse is a second or two ahead of its schedule, sometimes a second behind; these discrepancies must be explained by the professional astronomer. One must have a telescope, a watch and access to the correct time. The error of the watch is found before and after the eclipse, so that the true

mean solar time is known to a quarter-second.

The eclipse was not total at any place on earth—there is no total eclipse this year, except on other planets, where they may be everyday affairs. But the sun and moon went through the same performance as at the time of totality, only the earth was not in place. That is to say, the umbra or complete shadow was there, as it always is, but was falling in space and missing the surface of our globe by miles. Had we ascended into the stratosphere or above, at the right place above this continent, we could have had the full benefit of totality, or at least of an annular eclipse, according to circumstances of the moon's distance from the earth, and the earth's distance from the sun. If totality took place, then from this unique position we would have been impressed with the superb color effects of the corona, prominences and chromosphere, and with an intense black sky, brilliant stars without a sparkle, and meteors flying by—dark and cold if above the earth's atmosphere—all to be witnessed in the daytime.

On the surface only the outer shadow of the moon struck the earth, and it first touched the globe off the coast of Lower California. This shadow was tangent to the earth's surface at this point at sunrise. It then raced across the country at about 1,600 miles an hour, covering the entire United States and most of Canada, and leaving the surface near the southeast coast of Greenland at sunset, when it was again tangent to the surface of our planet.

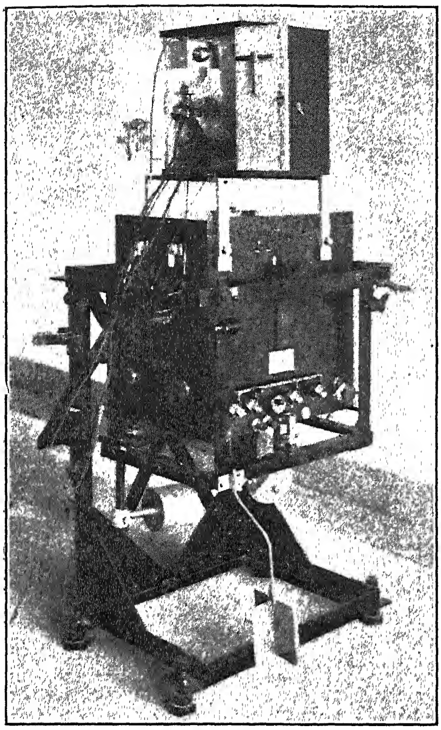
In 1935 we have seven eclipses (the greatest possible number), the remaining ones being: on June 30, a partial eclipse of the sun, that travels across the north pole; on July 16, a total eclipse of the moon, visible fortunately from most of North America; another partial eclipse of the sun on July 30, between South Africa and Antarctica; and on December 25, an annular eclipse of the sun in Antarctica, the central line going within 2° of latitude of the south pole. Next year, there will not be any eclipse visible in North America.

CLYDE FISHER AND HUGH S. RICE
AMERICAN MUSEUM
OF NATURAL HISTORY

THE GRAVITY-AT-SEA EXPEDITION

ON November 14, 1934, Dr. F. A. Vening Meinesz, of the Netherlands Geodetic Commission, left Holland on a submarine of the Dutch Navy on his eleventh expedition for the determination of gravity at sea. The observations will be made in the Atlantic and Indian Oceans. According to an itinerary received from Dr. Meinesz, he will cross the Atlantic twice on this expedition, once close to the Equator and once in the South Atlantic. He will then cross the Indian Ocean from South Africa to Australia and from there will proceed to Java. Among the ports at which the submarine will stop for refueling and to give much-needed rest to the personnel are Funchal, Dakar, Pernambuco, Buenos Aires, Capetown, Mauritius and Freemantle. Altogether the expedition will take about eight months from the times it leaves Holland until it reaches Java.

With the exception of the expedition from Holland to Java by way of the Panama Canal, made by Dr. Meinesz in 1926, the present one is the most extensive and one of the most important of the many expeditions for determining gravity at sea with modern accuracy. It will furnish much-needed gravity data in the Southern Hemisphere, and it will contribute toward a general gravimetric survey of the Atlantic Ocean which is needed in geophysical and geological studies of that area.

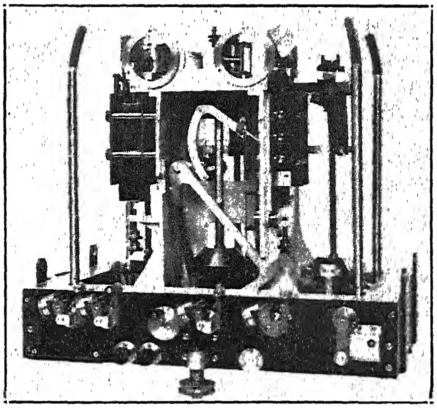


MEINESZ GRAVITY-AT-SEA APPARATUS
THE LARGER BOX CONTAINS THE PENDULUMS, THE UPPER AND SMALLER BOX THE PHOTOGRAPHIC RECORDING DEVICE. THEY ARE SUPPORTED IN GIMBALS, FOR EVEN AT A DEPTH OF 10 FATHOMS THE SUBMARINE IS STILL SOMEWHAT AFFECTED BY WAVE MOTION.

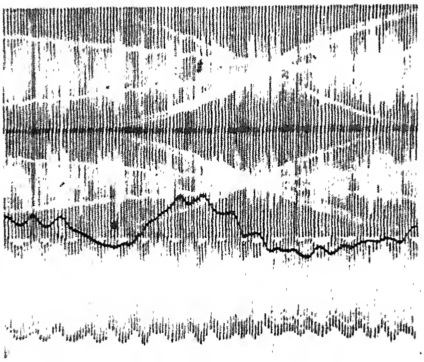
A very large proportion of all the gravity determinations in the world have been made in the Northern Hemisphere and, except in the East Indies, where Dr. Meinesz made an intensive gravimetric survey of the water areas a few years ago, most of these determinations are north of the Torrid Zone. The need for more work in the Southern Hemisphere, both on land and at sea, has long been realized. The International Association of Geodesy has called on the scientific organizations of the different countries to do everything possible to overcome this lack of data as rapidly as possible. England and The Netherlands have responded to this appeal; England by sending a gravity party to East Africa, and Holland by financing the present expedition.

The new gravity measurements in the Atlantic Ocean will be of special interest for several reasons. First, they should be of help in indicating whether or not a longitude term is needed in the formula which denotes the change of gravity over the sea-level surface of the earth; second, they will help more nearly to fill the gap in gravity values between the Eastern and Western Hemispheres; and third, they should throw some light on the formation of the mid-Atlantic ridge from the standpoint of isostatic equilibrium. This gravimetric survey of the Atlantic will undoubtedly indicate critical areas where it will be desirable to carry on intensive surveys.

Other countries of the world beside The Netherlands should take an active part in making the detailed surveys that may be needed in this area. The United States Navy in cooperation with other organizations in this country and with the assistance of Dr. Meinesz has done valuable gravity-at-sea work in the West Indies. It is hoped and expected that



INSIDE VIEW OF MEINESZ APPARATUS
THE RECORDING IS DONE IN SUCH A MANNER THAT TWO PENDULUMS SWINGING IN OPPOSITE PHASE ARE COMBINED TO GIVE A THEORETICAL PENDULUM WHICH IS NOT AFFECTED BY THE SLIGHT HORIZONTAL ACCELERATIONS OF THE SUBMARINE.



SECTION OF RECORD
MADE BY MEINESZ APPARATUS. IT SHOWS THE OSCILLATIONS OF TWO THEORETICAL AND ONE REAL PENDULUM, THE SECOND-TICKS OF TWO CHRONOMETERS, THE TEMPERATURE OF THE AIR WITHIN THE PENDULUM CASE AND THE ENDWISE TILT OF THE PLANES ON WHICH THE PENDULUMS SWING.

they will undertake more work of this kind in the future. Italy and France have made a number of determinations in the Mediterranean Sea. Geophysicists in many other countries are fully aware of the importance of determining gravity over the great water areas of the world, and are urging their navies to undertake this valuable peace-time work.

At present, gravity-at-sea determinations are not practicable except on a submarine, which must be submerged deep enough to be only slightly affected by wave motion. The cost of doing the gravity work at sea involves only that for fuel and the salaries and traveling expenses of the observers, other than the pay of the officers and the members of the crew, which goes on whether the ship is at the dock or at sea. Dr. Meinesz and the Netherlands Navy have blazed the trail. Others should help them in this great undertaking of determining gravity over the oceans.

C. H. SWICK

U. S. COAST AND GEODETIC SURVEY

THE SCIENTIFIC MONTHLY

APRIL, 1935

LABORATORIES IN THE STRATOSPHERE

By Dr. LYMAN J. BRIGGS

DIRECTOR, NATIONAL BUREAU OF STANDARDS; CHAIRMAN, SCIENTIFIC ADVISORY COMMITTEE OF THE NATIONAL GEOGRAPHIC SOCIETY—ARMY AIR CORPS STRATOSPHERE EXPEDITION

THE conquest of the upper air has written a most interesting chapter into the story of human endeavor. Over thirty years ago two German pilots, in the open basket of a balloon, reached the unprecedented altitude of 35,420 feet. Men can not live long at such altitudes without an extra oxygen supply, and these daring pilots barely escaped with their lives. Their feat remained unchallenged for more than twenty years.

But the development of the airplane, together with the oxygen mask, opened up a new line of attack, and in 1923 Lecointe of France climbed to a height of 36,550 feet. Since that time, the altitude record for airplanes has passed in succession to the United States, Germany, the United States, England, France and Italy, where last year Donati climbed to the astonishing height of 47,350 feet.

In 1927 Captain Gray, of the United States Army, made a valiant attempt to bring the title back to the balloonists. Twice during that year Gray reached an altitude of 42,470 feet, which exceeded all airplane records up to that time. On the first flight he was obliged to make a parachute jump, and after the second flight he was found dead in the basket of his balloon, his oxygen supply having failed. Unhappily, neither of these flights could be officially credited, because under the rules of the game the pilot must land his craft safely.

With Auguste Piccard's invention and successful use of an airtight gondola in a balloon flight in 1931, the whole picture once more was changed. The gondola is closed while the air pressure is still relatively high, and the carbon dioxide exhaled by the occupants is absorbed by chemicals. The balloonists are free to move about while making their observations, and the gondola protects them to a considerable extent from the intense cold. The altitude reached no longer depends upon the fortitude of the pilots, but is determined by the size of the balloon.

In his first flight in 1931, Piccard reached an altitude of 51,775 feet, thus eclipsing by more than 4,000 feet the highest altitude ever attained in an airplane. In 1932 he made a second flight to a height of 53,150 feet. Since that achievement, six stratosphere flights have been made, two in Russia, one in Belgium and three in America. The present record is held by Commander Settle and Captain Fordney, who in their *Century of Progress* balloon in 1933 reached an altitude of 61,237 feet.

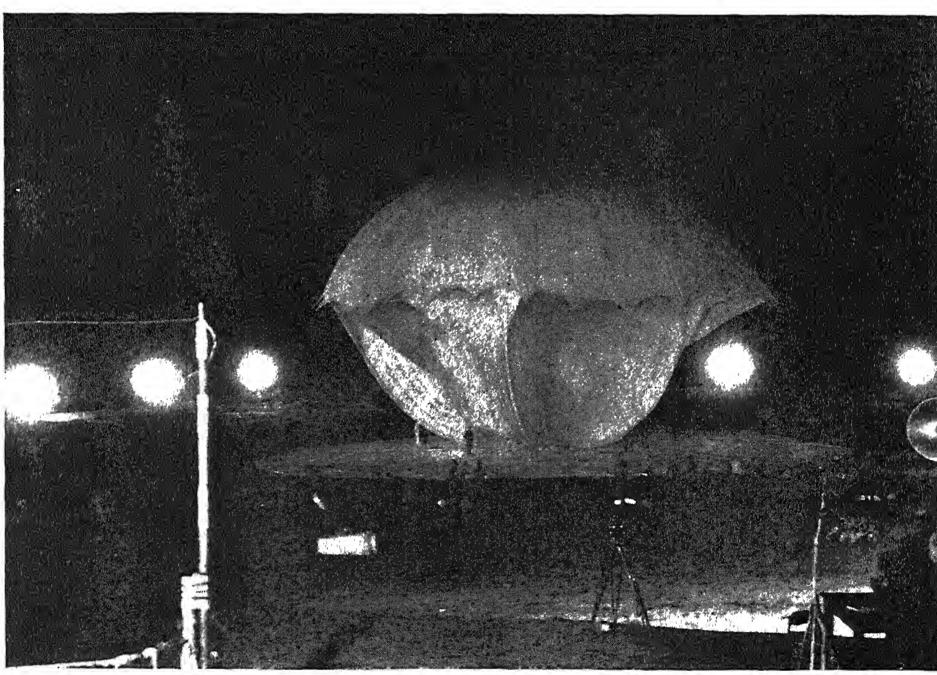
In the intense sunlight of the stratosphere the gas in the balloon becomes heated far above the temperature of the surrounding air. When the balloon descends, this superheat is gradually lost and the buoyant gas diminishes in volume. The lift decreases, just as if gas had actually been discharged from

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

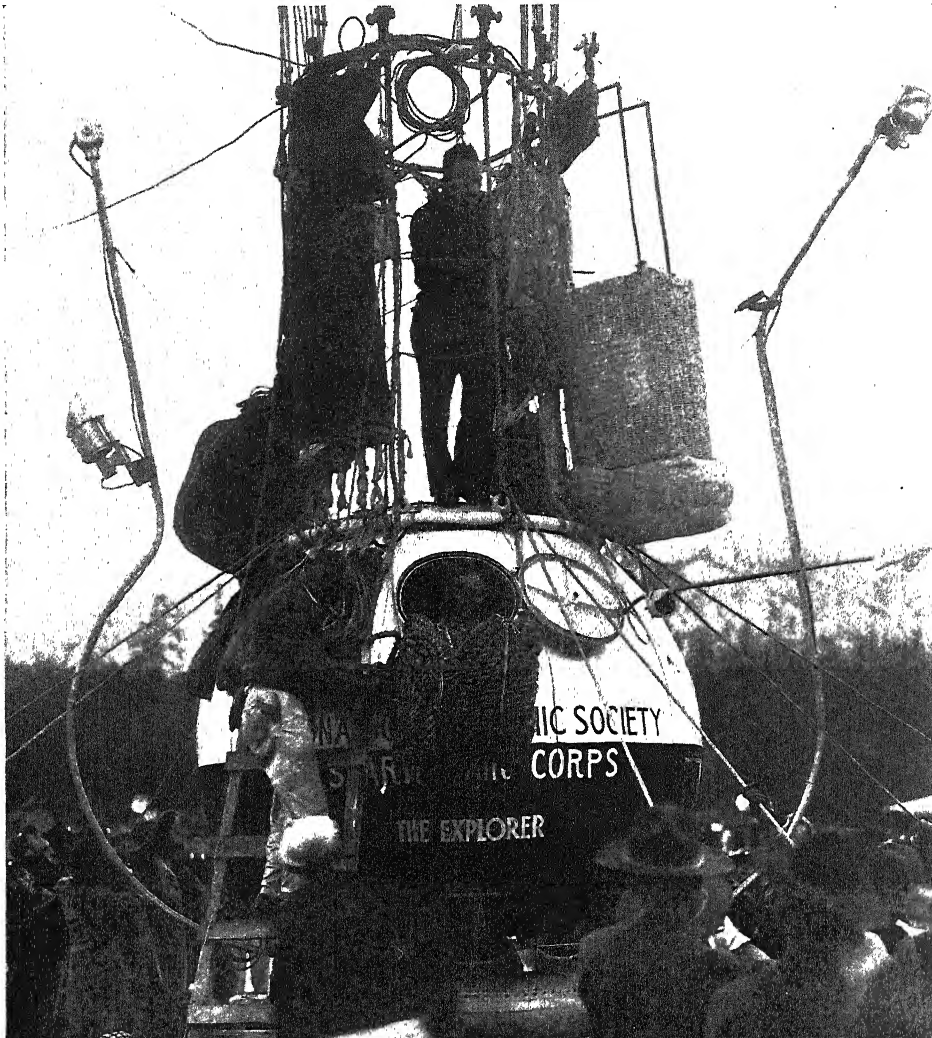
THE STRATOCAMP IN THE BOTTOM OF THE BOWL

THE GREAT BALLOON IS STORED IN ITS BOX IN THE CENTER OF THE CIRCULAR RING. THE GONDOLA IS SEEN ON ITS TRUCK BETWEEN THE BALLOON AND THE CABIN. THREE ROWS OF HYDROGEN CYLINDERS ARE PILED AT THE LEFT AND THE CAMP TENTS ARE IN THE BACKGROUND.

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight
THE BEGINNING OF THE INFLATION



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight
THE INFLATION PROCEEDS



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

ABOUT READY TO GO.

THE LARGE SPECTROGRAPH IS IN ITS BASKET ON TOP OF THE GONDOLA. THE LIFTED ARMS CARRY THE ELECTRICAL THERMOMETERS AND THE FAN FOR TURNING THE BALLOON. MAJOR KEPNER STANDS ON TOP OF THE GONDOLA AND CAPTAIN STEVENS CAN BE SEEN THROUGH THE PORTHOLE.

the balloon. Unless a generous supply of ballast is kept in reserve at the highest point of the flight a dangerously rapid descent can not be checked.

Records recovered from the wreckage of the ill-fated Russian balloon indicated that it attained the astounding altitude of 72,000 feet. But the unfortunate Russian pilots, in their desire to gain altitude, failed to reserve sufficient ballast to check the rapid descent of their balloon, and all of them were killed.

While altitude records alone are of no great significance, they do provide a significant measure of accomplishment in the development of engines, airplanes and balloons, which can be utilized in undertakings of real importance. An

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE INFLATION IS COMPLETED

AND THE GUY ROPES ARE BEING PAYED OUT SO THAT THE GONDOLA CAN BE BROUGHT UNDER THE BALLOON.

altitude record was not the primary objective of any of the eight stratosphere flights I have mentioned. In each case scientific equipment was carried for the purpose of wresting from nature some of the secrets which are denied to us because of the blanket of air surrounding the earth. To discover them we must rise above this air blanket, putting as much of the atmosphere below us as possible.

The 1934 expedition of the balloon *Explorer,* under the joint sponsorship of the National Geographic Society and the Army Air Corps, was a further step in this direction. The purpose was to carry into the stratosphere substantial apparatus such as would be used for the

making of precise measurements in a laboratory on the ground if the blanketing atmosphere did not intervene. This apparatus weighed more than a ton. It was a load which no other balloon had ever been called upon to carry.

The gondola of the *Explorer* was in fact a floating laboratory. And to carry its great weight up into the extremely tenuous stratosphere, where the air pressure was less than one fifteenth that at sea-level, it was necessary to build a balloon far larger than had ever been built before. Auguste Piccard's balloon had a capacity of 500,000 cubic feet; the *Century of Progress* balloon, flown again last year by Dr. and Mrs. Jean Piccard, 600,000 cubic feet. The volume of the Russian balloon was about 900,000 cubic feet. The *Explorer* was a spherical balloon 179 feet in diameter, with a capacity of 3,000,000 cubic feet.

The advisory committee charged with the task of planning the scientific program received so many suggestions regarding desirable stratosphere observations that even with the remarkable facilities at hand much choosing was necessary. One of the main problems proved to be the discarding of investigations which could not be carried out within the space and weight limitations of the gondola.

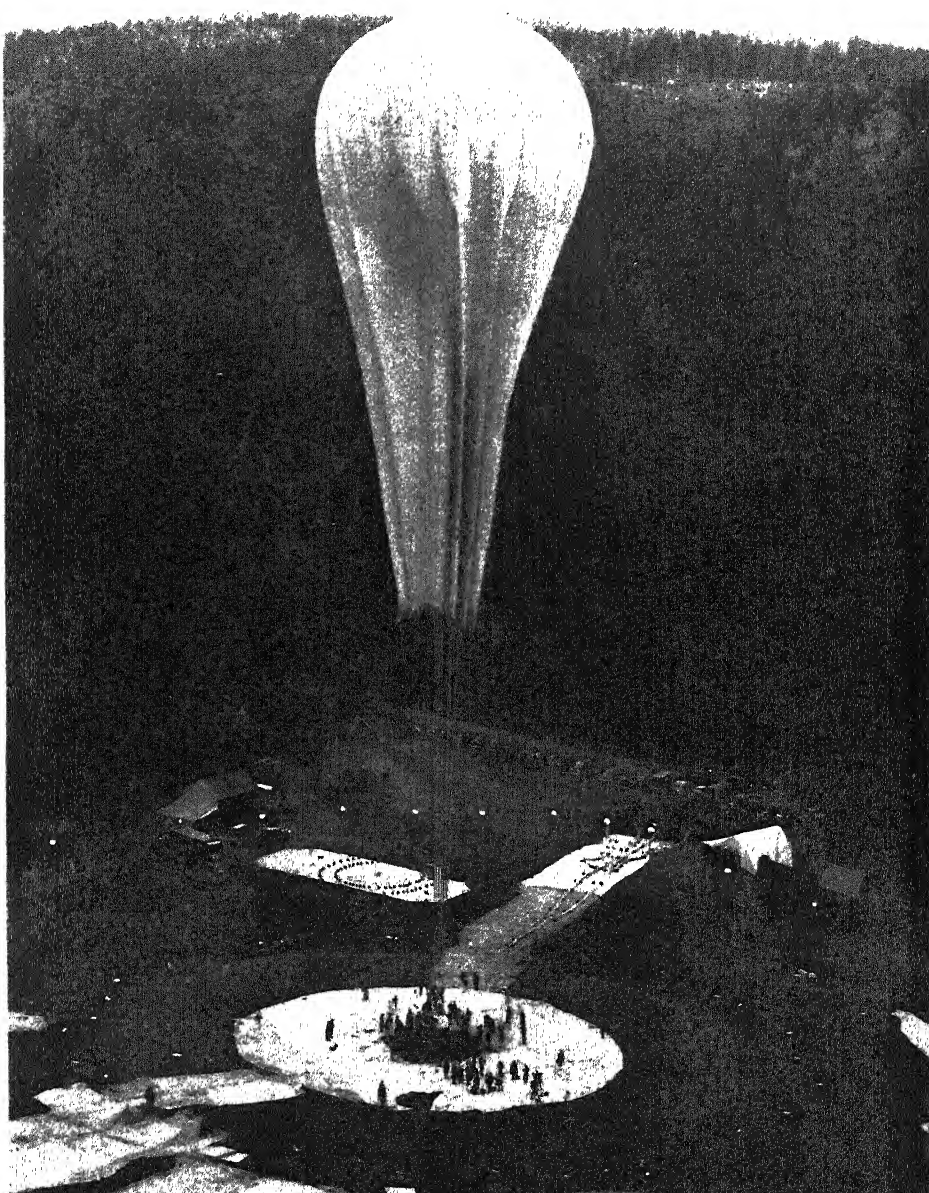
The scientific program centered broadly on four objectives: (1) the study of the intensity and direction of cosmic radiation at high altitudes; (2) the determination of the position and distribution of the ozone layer in the stratosphere; (3) the composition of air samples collected in the stratosphere; and (4) the comparison of altitude determined from photographs of surveyed country below the balloon with the altitude computed from the pressure and temperature of the air at the instant the photograph was made.

The apparatus included three electroscopes for studying the change in intensity of cosmic rays, provided by Dr. Millikan and Dr. Neher, of the California Institute of Technology. One of these electroscopes was surrounded by a massive shield consisting of 600 pounds of lead shot, so arranged that it could be drawn off quickly and used as ballast if necessary. The second electroscope was shielded by 200 pounds of shot, while the third was left bare, accessible even to the mildest cosmic radiation.

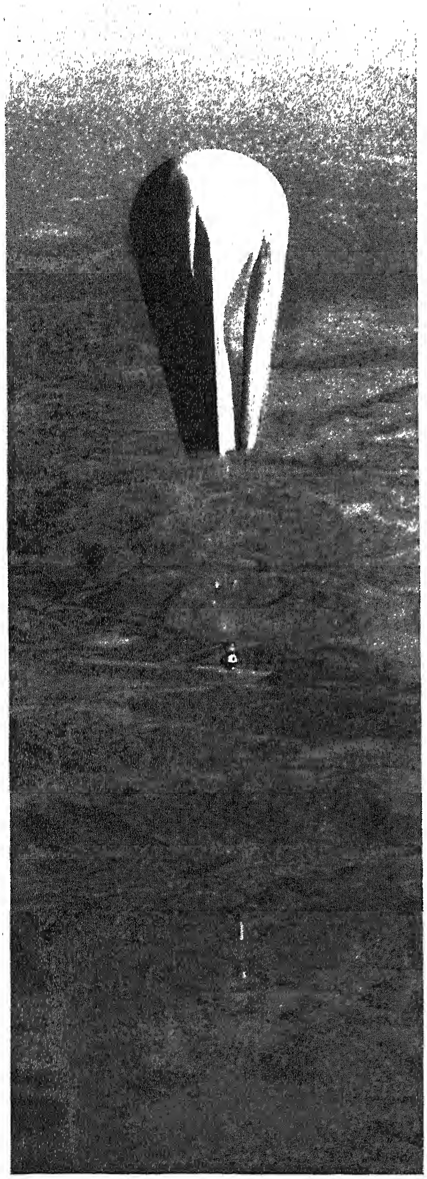
Dr. Swann and Dr. Locher, of the Bartol Research Foundation, Franklin Institute, installed eight cosmic ray "telescopes" for studying the direction of the cosmic radiation. Two were placed horizontally, two vertically, while the others were fixed at intermediate angles of thirty and sixty degrees, all the instruments being located in the same vertical plane. This made it possible to count the rays coming in from the direction in which the telescopes were pointed and actually to sweep the heavens by turning the gondola about a vertical axis. Captain Stevens provided for this by mounting a small motor with a propeller at the end of a long arm projecting out horizontally from the gondola. In this way the great balloon could be slowly turned at will in either direction or kept oriented in any desired position.

The spectrographic equipment for studying the position and distribution of the ozone layer was supplied by Dr. O'Brien, of the University of Rochester, and by the Bausch and Lomb Optical Company. Two of the spectrographs were carried inside the gondola, while the third was suspended on a rope 500 feet below, so as to be out of the shadow of the balloon at all times. Other instruments included those for measuring the temperature and the pressure of the outside air, while in the top of the gondola were the large evacuated flasks for securing air samples from the stratosphere.

During the inflation and launching of



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight
ATTACHING THE GONDOLA TO THE BALLOON



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

GOING UP.

ELEVATION ABOUT 15,000 FEET. SPECTROGRAPH WITH ITS PARACHUTE HAS BEEN LET DOWN BELOW THE GONDOLA.

a balloon as large as the *Explorer* the air must be still. The great bag would be wholly unmanageable in a wind. After much searching, a natural bowl in the Black Hills near Rapid City, South Dakota, was selected by Major Kepner as the site of the take-off. This bowl is nearly surrounded by cliffs and hills four to five hundred feet high, affording the needed protection from winds which might arise during the inflation. Since it was expected that the balloon would drift several hundred miles to the east or southeast, this location seemed also to insure a landing in open prairie country, where the balloon would not be subject to damage by alighting in a forest.

I have never seen a more remarkable example of cooperation for scientific objectives than that which sprang into action upon the selection of the site for the Stratocamp. With the National Geographic Society generously sponsoring the flight, footing the bills and making the enterprise possible, the Army Air Corps provided flight personnel of outstanding experience, and also assigned two airplanes with personnel for the use of the expedition. Through the courtesy of the officers of Fort Meade, a military camp was established in the bowl, which provided guards, mess equipment, a hospital unit and tent facilities for the scientific staff. A road was built into the bowl by state and local officials, Rapid City provided a fire engine with personnel for additional fire protection, and the South Dakota National Guard transported the cylinders of hydrogen. The American Telegraph and Telephone Company contributed telegraph lines and instruments necessary for the weather service. Experienced men detailed by the U. S. Weather Bureau and the U. S. Signal Corps prepared two weather maps at the camp each day as suitable conditions for the flight were anxiously awaited. The National Broadcasting Company installed in the gon-

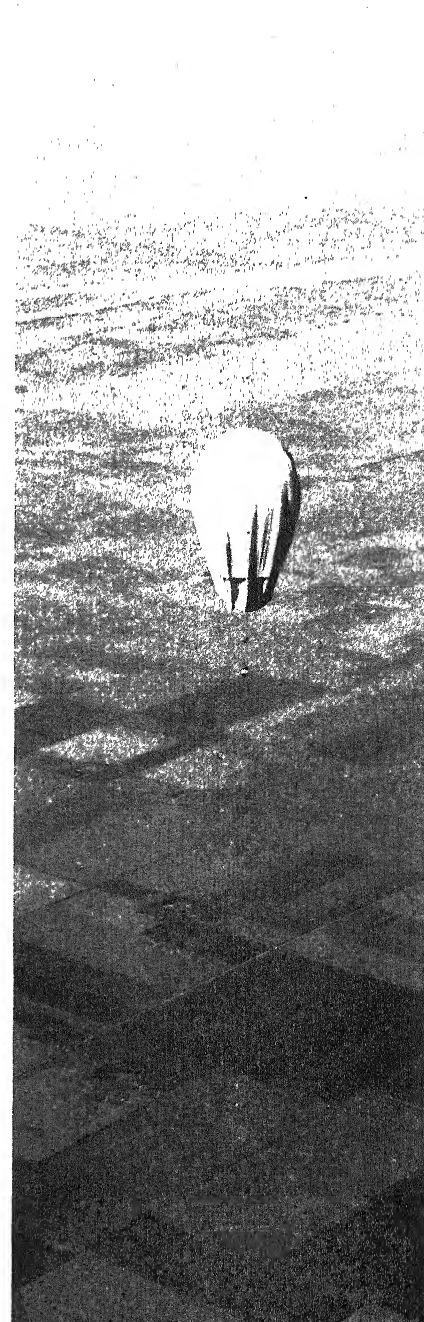
dola the special transmitting and receiving equipment, providing dependable communication between gondola and ground.

Finally on July 27, 1934, the weather map indicated the favorable conditions so long awaited. Clear weather was promised to the east for the following day, with no thunderstorms indicated and low wind velocities probable at the camp.

The great balloon was taken out of its box, where it had been stored for more than six weeks, and placed on a canvas-covered space that had been prepared for it. The upper part was carefully unfolded or "blossomed out" into a circular disk about a hundred feet in diameter. Canvas tubes were run from the balloon to the hydrogen supply stored in over a thousand heavy-walled cylinders, each under a pressure of 2,000 pounds per square inch. At eight o'clock in the evening the inflation was begun, and by midnight it was completed, with something over 200,000 cubic feet of hydrogen in the big bag. Floodlights surrounding the field made it possible to carry on all necessary operations without difficulty.

Balloons which travel at relatively low altitudes are completely filled with gas when they leave the ground. This would be wasteful of hydrogen in the case of a stratosphere balloon, because the hydrogen would be constantly expanding and flowing out of the bag as the balloon rose to levels where the air is less dense. The *Explorer* therefore was inflated to only about 7 per cent. of its total capacity, enough to fill the bag 100 per cent. at an altitude of 65,000 feet, from which point upward hydrogen would flow out continuously through the appendix.

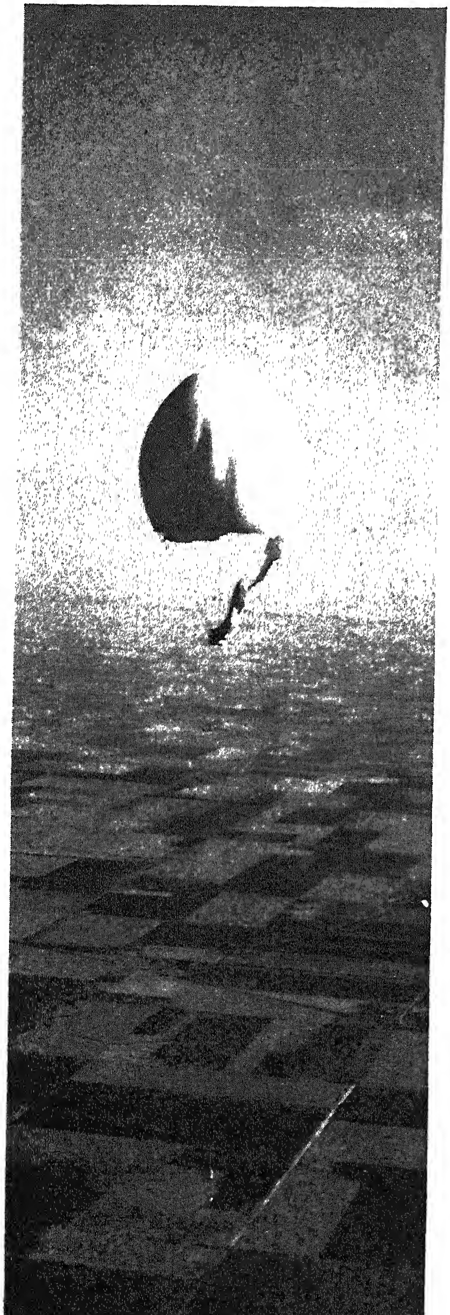
The shape of the partially filled balloon at take-off resembled a gigantic exclamation point, with the hydrogen gas rounding out the top and the gondola forming the dot below. When the inflation was completed, the thirty-six mooring ropes holding the great bag to the earth were gradually slackened



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

COMING DOWN

FROM A MAXIMUM ELEVATION OF 62,000 FEET. BOTTOM FABRIC HAS DROPPED BELOW THE CATENARY BAND TO WHICH THE ROPES SUPPORTING THE GONDOLA ARE ATTACHED. NORTH PLATTE RIVER IN BACKGROUND.



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE BOTTOM TEARS AWAY.

NOTE THE CHANGE IN SHAPE OF THE BALLOON.

away, and the gondola with its load of carefully tested instruments, ballast and accessories, was wheeled out on its special car and attached to the balloon. Major Kepner, Captain Stevens and Captain Anderson climbed aboard. The ballast was adjusted to give the desired lift, and as the sun began to light the peaks of the adjacent hills Major Kepner gave the word to let go. From the rim of the bowl a great cheer went up from the twenty thousand people who had gathered to see the great balloon rise silently, gracefully, majestically out of the bowl.

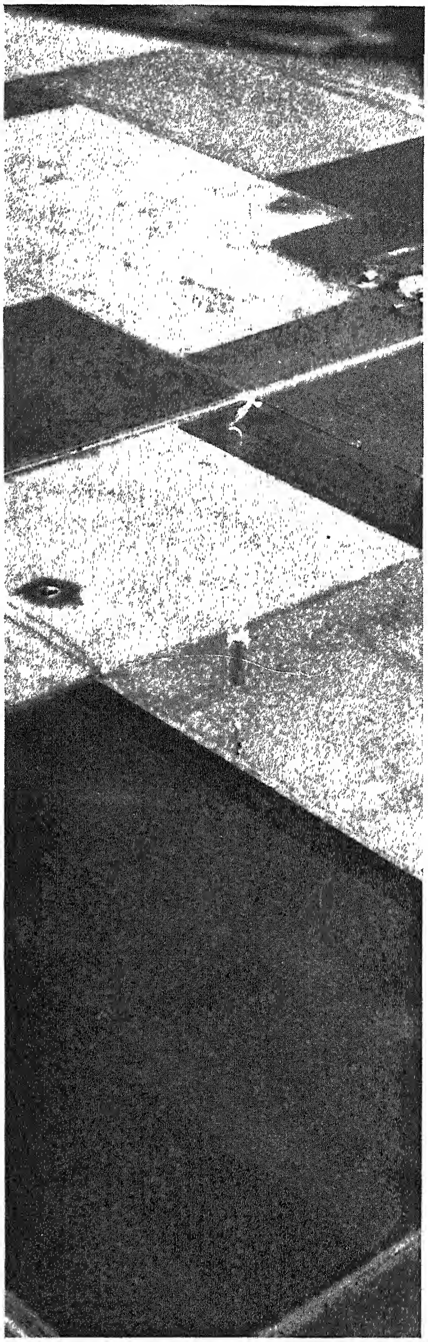
The plan was to stop at 40,000 feet, and again at 60,000 feet for observations, and then to go on up to the ceiling of the balloon. The stop at 40,000 feet was made according to schedule, and the pilots then proceeded to the 60,000 foot level. The balloon was now nearly full, and in looking up at it through a window in the top of the gondola, they noticed several tears in the bottom of the bag. That was the first indication of trouble.

A new method of folding the balloon for storage had been used to facilitate handling during inflation, the lower part being inverted and tucked up into the main body of the bag. It was believed that as the balloon expanded this tucked-up fabric would gradually drop to its normal position. After the crash it was found that during the long period of waiting for favorable weather, this lower part had become stuck or pasted, so to speak, over folds in the main body of the balloon, so that, when the balloon filled and these folds were forced open by the expanding gas, the bottom fabric was torn.

After spending about half an hour at the 60,000 foot level, the balloon began a gradual descent. At 18,000 feet the gondola was opened and the men climbed out on the top with their parachutes to inspect the damage to the balloon. The

tears had increased in size, and as the descent continued the entire bottom of the bag began to tear away, and finally dropped down on the gondola. It was then possible to look directly up into the balloon, which had now become in effect a parachute partly filled with hydrogen gas, which was rapidly mixing with air to form an explosive mixture. At an elevation of about 3,000 feet an explosion occurred, and the entire top of the balloon was torn away. The gondola now had nothing to support it, and was falling like a plummet. In less than twenty-five seconds the men had taken safely to their parachutes and the gondola with its load of instruments had crashed in a Nebraska corn field.

From the scientific standpoint the flight at first seemed a complete failure, for the records were taken on photographic films which were broken open and exposed to broad daylight amidst the wreckage of the gondola. But when films which remained tightly wound on their spools were developed the greater part proved to be still in good condition even when outer edges were badly fogged. Even the photographs made with the vertical camera to determine altitudes, which at first were thought hopelessly fogged, were found legible up to the highest altitude attained. The suspended spectrograph had been cut loose before the explosion occurred and landed safely on its own parachute. It was still busily taking records when recovered. And so a much larger part of the records was salvaged than the most optimistic of us thought possible immediately after the crash. The results of the scientific observations, together with a full account of the flight, and a detailed study of the cause of the failure of the balloon will be given in a special publication on the flight of the *Explorer* which will shortly be issued by the National Geographic Society.

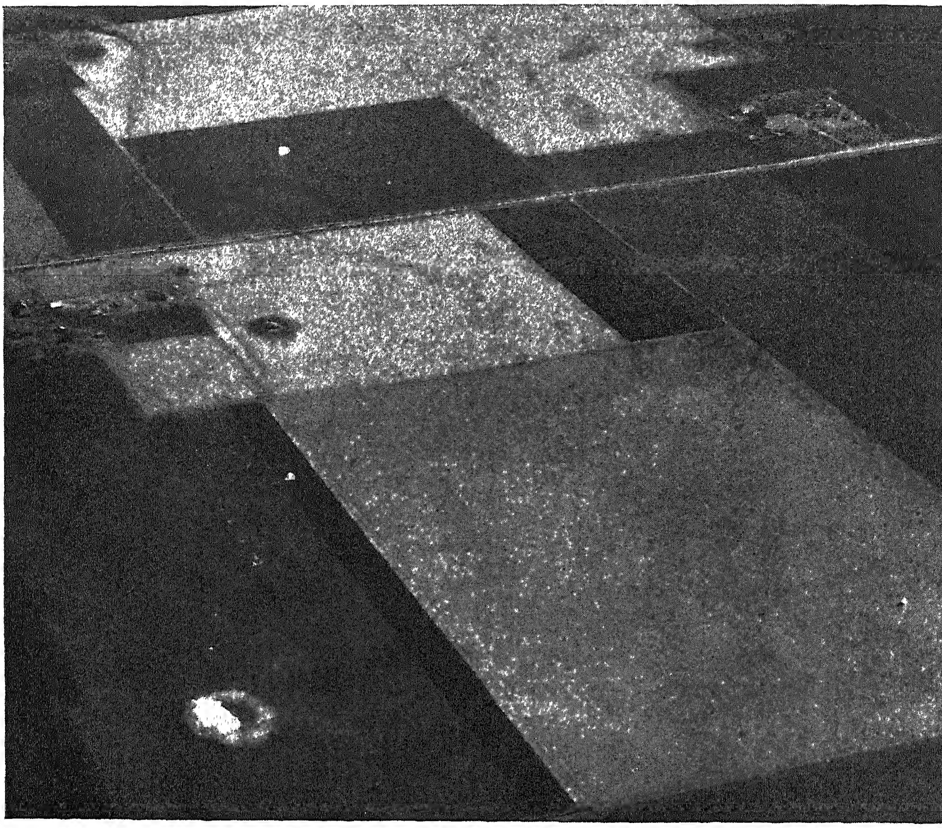


Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE BALLOON EXPLODES

AND THE GONDOLA FALLS LIKE A PLUMMET.

Undaunted by the loss of the balloon,



Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

THE END OF THE EXPLORER.

MAJOR KEPNER AND CAPTAIN STEVENS ARE ABOUT TO LAND IN THEIR PARACHUTES. THE SUSPENDED SPECTROGRAPH WHICH HAD BEEN CUT LOOSE BEFORE THE EXPLOSION OCCURRED CAN BE SEEN WITH ITS PARACHUTE SOME DISTANCE TO THE RIGHT IN THE ADJACENT FIELD.

the National Geographic Society and the Army Air Corps are busily planning another flight for the coming summer. The construction of the balloon, the gondola and the instruments is already under way, and the experience gained during the first flight is being fully utilized. As additional safety precautions, the cap of the balloon and the bottom will be made of somewhat heavier fabric and, most important of all, the balloon will be inflated with helium instead of hydrogen, eliminating all possible danger of explosion. To offset the added weight of the balloon and the use of helium, which is less buoyant than hydrogen, the new balloon will be made somewhat larger, with a capacity of about 3,700,000 cubic feet. It is planned to make the second ascent from the same bowl in the Black Hills of South Dakota.

The award of the Distinguished Flying Cross of the United States Army to the three brave men who made the flight has given the deepest satisfaction to every one associated with the expedition. While Major Kepner has been detailed to other duties which will keep him from participating in the coming flight, Captain Stevens and Captain Anderson are now preparing to take the new laboratory into the stratosphere.

STABLE AND UNSTABLE NUCLEI

By Dr. RUDOLF W. LADENBURG

BRACKETT RESEARCH PROFESSOR OF PHYSICS, PRINCETON UNIVERSITY

Two years ago when I reported in this journal on the fundamental units of the physical world,[1] I had to end with the question: What are those fundamental units? At that time had just been discovered the positive electron, the real counterpart of the negative electron, probably having the same small mass and the same elementary charge, but with the positive sign, and a beginning had been made in the study of the properties of the neutron, the uncharged particle of about the mass of the hydrogen atom. The question was: Are these all elementary particles? Or is the neutron perhaps a combination of the proton (that is the nucleus of the hydrogen atom) and of a negative electron—or is the proton a complex particle, composed of a neutron plus a positive electron?

To-day there is no definite answer to this question—but perhaps the question has lost its sense. We know the building stones of the atoms. They consist of positively charged heavy nuclei surrounded by the light negative electrons. We know the arrangement of these electrons in the different atoms, but we are just beginning to learn something about the nucleus. The radioactive phenomena, the emission of alpha, beta and gamma rays, the transmutation of elements—all these are processes due to the nuclei.

We know further that one of their building stones is certainly the proton, but there ought to be another kind of particles which hold the protons together—otherwise these would repel each other and there would be no stable nuclei. For a long time it was understood that the negative electrons are the other building stones, but to-day we doubt whether free electrons exist at all in the nuclei. They are certainly ejected by natural and by artificially produced radioactive atoms and appear as "beta particles," but they are no longer thought of as free units in the nuclei. We have important experimental and theoretical reasons for this revolutionary idea. Popularly expressed, the electron is too big for the small nucleus; more exactly, but less clearly: the mass and the momentum of the electron is so small that the corresponding DeBroglie wave has no room in the nucleus. What, then, instead of the electrons, does hold the different protons together? It is the neutrons, according to the modern conceptions of Heisenberg, Wigner and others. In spite of their lack of electric charge, the neutrons are bound by strong attractive forces to the protons when they are very near together. As a matter of fact, the nature of these forces is one of the great problems of to-day, but they certainly exist and are much stronger than the repulsive forces between proton and proton.

The numbers of the particles of these two kinds determine the characteristic constants of the nucleus: the positive charge Z equals P, the number of protons, and the difference between the mass $\overline{M}$ and the charge, $\overline{M} - Z$, equals N, the number of neutrons. $\overline{M}$, which equals $P + N$, is not the exact mass of the atom —it is the nearest whole number, the "mass number," if the unit of mass is 1/16 of that of the oxygen atom. The chemists, especially Berzelius, displayed a deep insight into nature when they chose this unit. Only on account of this

[1] THE SCIENTIFIC MONTHLY, 36: 465–467, May, 1933.

choice is the deviation of the exact mass M from the whole number for all nuclei very small, and only when measured in those units is the number of neutrons given in such a simple way. The knowledge of M gives us not only the number of neutrons but also the energy content of a nucleus: the difference of this mass M from the sum of the masses of protons and neutrons, "the mass defect," is equivalent to the energy set free in the building of the nucleus. The same energy would have to be put into the nucleus in order to overcome the attracting forces between protons and neutrons and break it into single fragments. Einstein's law, the equivalence of mass and energy, determines in this way one of the fundamental properties of the nucleus.

The simplest compound nucleus is that of deuterium, the heavy isotope[2] of hydrogen of mass 2 discovered three years ago by Urey. This nucleus, baptized recently "deuteron," in order to avoid confusion of the older name "deuton" with the "neutron," is abbreviated by the symbol ${}^2_1D$; the upper index designates its mass, the lower one its charge, as with the symbols ${}^1_1H$ for the proton and ${}^1_0n$ for the neutron. The "mass defect" and therefore the binding energy of the deuteron is about 2 million electron volts (eV), as determined from the recent discovery of its disintegration into a proton and a neutron by means of hard gamma-rays of an energy[3]) of 2.6 million eV. The same experiment shows that the mass of the neutron is very nearly the same as that of an hydrogen atom, settling a much-discussed question. This result is of fundamental importance. If the masses of the hydrogen atom and the neutron are equal, then both are energetically stable. If, for example, the neutron were distinctly heavier, it would disintegrate spontaneously into a proton and an electron, for such a process would set free the amount of energy equivalent to the surplus of the mass of the neutron.

The next simple nuclei are ${}^3_1H$, the third isotope of hydrogen, and ${}^3_2He$, the isotope of ordinary helium ${}^4_2He$, both particles discovered only last year in the Cavendish Laboratory by bombarding deuterium with fast-moving deuterons. The two nuclear reactions are

$${}^2_1D + {}^2_1D \rightarrow {}^3_1H + {}^1_1H$$

and

$${}^2_1D + {}^2_1D \rightarrow {}^3_2H + {}^1_0n$$

Knowing the energy of the impinging and produced particles and the masses of ${}^2_1D$, ${}^1_1H$ and ${}^1_0n$, one finds the masses of ${}^3_1H$ and ${}^3_2He$ by means of the equivalence between mass and energy. They come out so nearly equal that one could almost expect that ${}^3_2He$ disintegrates spontaneously into ${}^3_1H$ with emission of a positive electron. Careful experiments in the Palmer Physical Laboratory have shown that this is not the case; both are stable, their mean lifetime being at least ten million years. The mass difference of ${}^3_2He$ against ${}^2_1D$, which has just one proton less, is much smaller than the mass of the proton, showing that the binding of a proton to a deuteron means an energy gain of nearly 5 million eV. In other cases this gain is two or three times larger. The binding energy of the very stable helium nucleus is even 27 million eV. Such enormous energies are stored up in the nuclei. That is why even relatively slow protons of only 30,000 eV when bombarding lithium, for example, are able to split its nucleus into alpha particles—*i.e.,* He nuclei of many million eV. kinetic energy, according to the reaction

$${}^7_3Li + {}^1_1H \rightarrow {}^4_2He + {}^4_2He.$$

In a similar way is the other lithium-

[2] "Isotope" is the name used for atoms of different mass and of the same nuclear charge Z which occupy the same place (τόπος) in the periodic table of the elements.

[3] The energy of a light quantum or a particle is measured by the number of volts which has to be applied to an electron for giving it the same kinetic energy. 1 million eV. corresponds nearly to 1/1000 of our mass units using the Einstein relation between mass and energy.

isotope ^6_3Li split by bombarding deuterons into alpha particles of even higher energy. The exact measurements of the kinetic energies and the nuclear masses involved in these reactions give a most sensitive test of Einstein's equivalence of mass and energy, which is confirmed within one per cent., a surprisingly high accuracy for such delicate experiments.

The kinetic energy of the bombarding particles plays only an unimportant rôle in this energy balance, but it is decisive for the efficiency of the process. The larger this kinetic energy, the greater is the probability for the particles to penetrate the potential barrier surrounding the positively charged lithium nucleus guarding against the approach of the similarly charged H or D particles. As a matter of fact, this barrier is very much higher than their kinetic energy, so that according to our classical mechanical ideas these particles would not be able to penetrate. The modern quantum and wave mechanical conceptions show, however, that for each particle of definite kinetic energy there is a certain probability of leaking through the potential wall and that this probability increases very much with increasing kinetic energy. Once having entered the interior of the nucleus—compare Fig. 1[4]—the impinging particle may be kept there on account of the strong binding forces exerted by the neutrons.

The potential wall around the nuclei increases with increasing charge, therefore the probability of transforming nuclei by accelerated positively charged particles decreases very much with increasing atomic number of the target. The heaviest nucleus thus far transformed in this way is that of the potassium atom.

Fast neutrons on the other hand penetrate nuclei much more easily, in fact there is very probably no potential barrier for neutrons. It seems that the smaller their energy, the better they enter sometimes the nuclei if only they come near enough. So was it even possible to transform the uranium atom, the heaviest of all known atoms, as Fermi and his collaborators showed half a year ago. The phenomena produced by the neutrons are especially interesting: The bombarded nuclei show sometimes "artificial radioactivity," going over first into unstable ones, which then emit mostly negative electrons spontaneously for some time, their mean lifetime being in some cases fractions of seconds, in others many minutes, hours or even days. Also alpha particles of radium are able to produce artificial radioactivity, as was shown by the French couple Curie-Joliot. In this case mostly positive electrons are emitted by the transformed unstable nuclei. How can this production of unstable nuclei be understood? Let us consider Fig. 2, the big table of the nearly 300 stable and radioactive nuclei known to-day. Their atomic number $Z = P$ (the number of protons) is plotted on the horizontal axis, the values of $\overline{M} - Z = N$, their number of neutrons, on the vertical axis, so that the different isotopes of one element lie vertically below one another. The full circles indicate the most abundant isotope, the open circles the less abundant ones, the crosses the radioactive atoms. This diagram shows many striking regularities which reveal some secrets of the arrangement of protons and neutrons: even numbers of protons and neutrons are very much favoured, elements with odd numbers of Z have never more than one or two isotopes, whereas elements with even numbers of Z have up to 9 or 11 isotopes (compare number 80 (Hg) or 50 (Sn)). This favouring of even numbers has been known for a long time in the relative abundance of the chemical elements in

[4] Fig. 1 is drawn for the case of the aluminium nucleus according to the study of its disintegration by alpha particles.

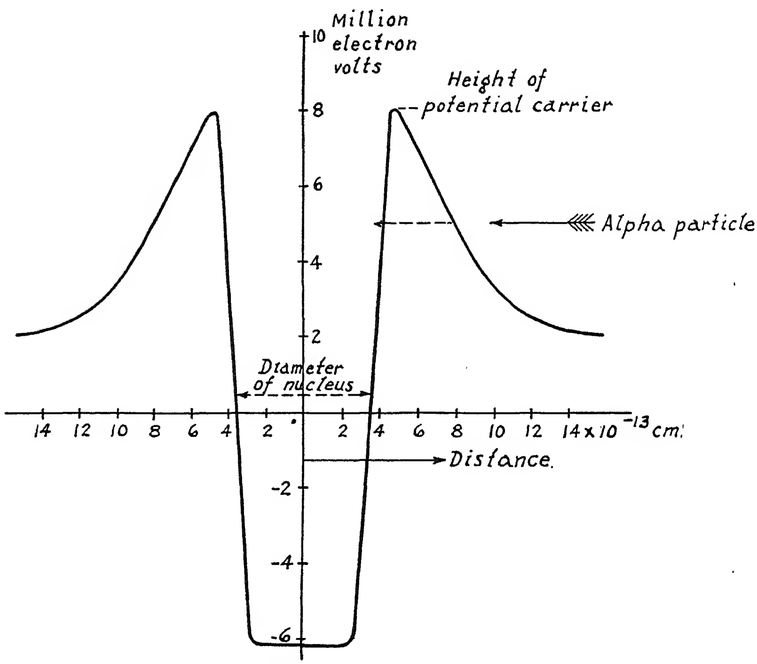
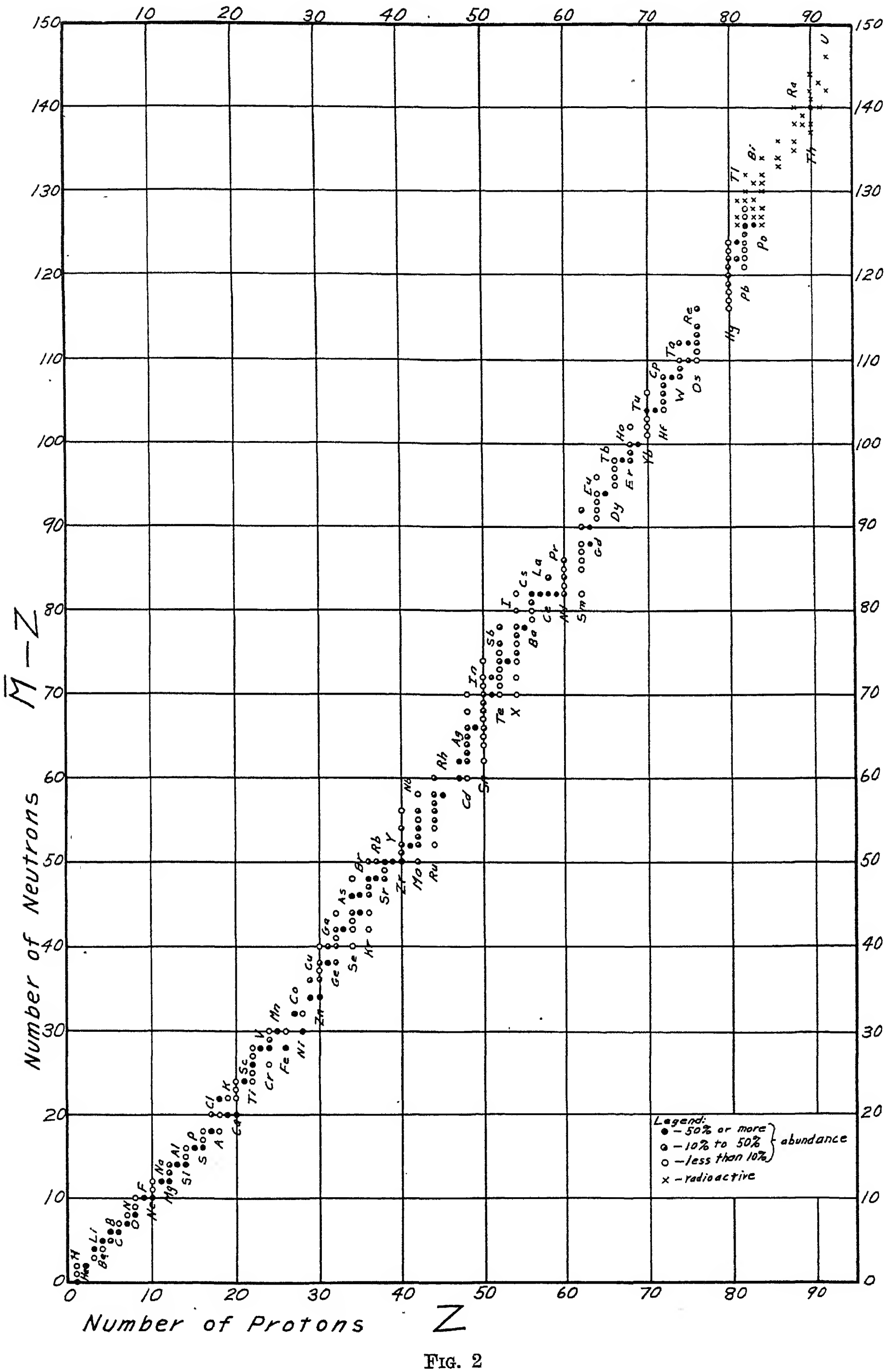


FIG. 1. POTENTIAL DISTRIBUTION OF ALUMINIUM NUCLEUS.

the material of the earth and also in the stars. Oxygen with 8 protons and 8 neutrons in its nucleus and silicon with 14 protons and 14 neutrons make up more than 75 per cent. of the weight of the lithosphere (surface of the earth). It seems that the pairing of protons and of neutrons plays a similar rôle in the nuclei as the pairing of electrons in the outer part of the atom, *viz.*, in its electron cloud. We see further in our diagram that up to number 20 (Ca) nearly all nuclei contain just as many neutrons as protons or perhaps one neutron more. For larger values of Z, the number of neutrons increases relatively to that of the protons, until the lead nucleus ($Z=82$) contains about 50 per cent. more neutrons than protons. The more protons are present, the more are auxiliary neutrons necessary for stabilizing the nucleus, that is, for balancing the repulsion between the protons. $Z=83$ is the nucleus with the highest atomic number which can be stabilized by a whole number of neutrons. All atoms of higher atomic number are unstable. Either they have a neutron too many and emit a negative electron spontaneously, or they contain a neutron too few and emit a positive particle. Up to $Z=83$ the nuclei are stable when they lie in the "Heisenberg valley," as we call the narrow region filled by the stable nuclei in our diagram, limited by the possible ratio of the numbers of neutrons and protons. It is an "energy valley," as the property of stability is connected with relatively low values of energy. Increase of the number of neutrons in a nucleus produced by bombarding with neutrons "raises" it on the left "side wall" of our valley; it becomes unstable and falls down in the valley by emitting a negative electron (compare Fig. 3, where the observed unstable nuclei produced by neutron bombardment are plotted as crosses (x)). If nuclei with too few neutrons are produced, on the right-hand side of



Number of Neutrons $\bar{M}-Z$
Number of Protons Z
Legend:
● – 50% or more
◐ – 10% to 50%
○ – less than 10%
abundance
× – radioactive

FIG. 2

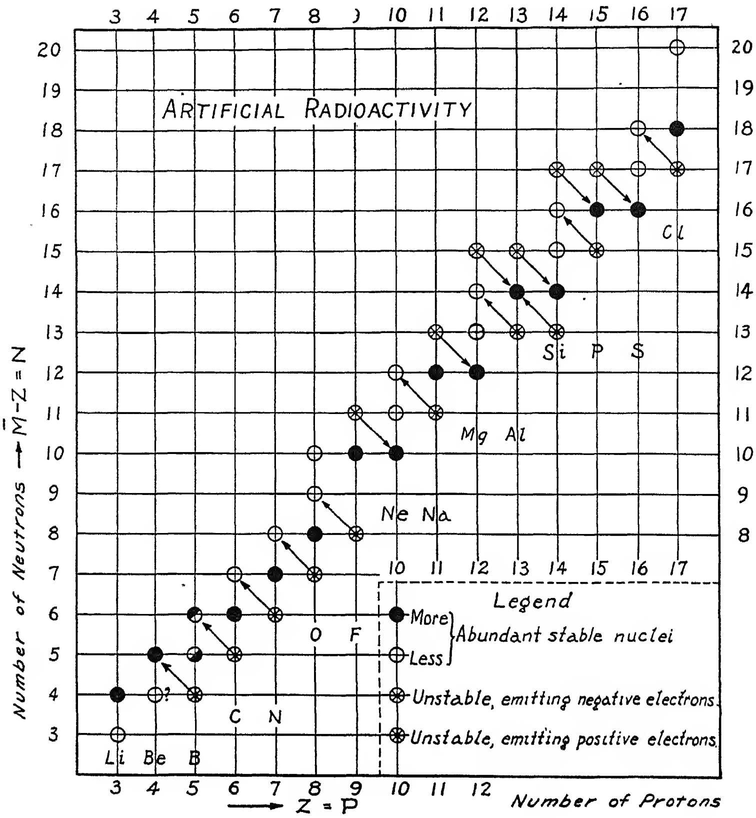


FIG. 3

the valley (plotted in Fig. 3 as stars (*)), they also become unstable, but emit positive electrons.

Our diagram shows that emission of a negative electron is equivalent to the loss of a neutron and a gain of a proton, that is, a transformation of a neutron into a proton inside the unstable nucleus. Emission of a positive electron, on the other hand, is equivalent with the transformation of a proton into a neutron. In this way it is possible to describe the emission of electrons from nuclei, although they do not contain free electrons. Electrons may be produced or destroyed in the nuclei in a way similar to that in which light quanta are emitted and absorbed by atoms, only the total amount of charge remains constant. We have no detailed picture of the process occurring in the reciprocal transformation of neutrons and protons; they may be considered as two different quantum states of the same "particle." It is idle to ask which is a fundamental unit. This question has lost its sense.

GREGOR JOHANN MENDEL

A BIOGRAPHICAL SKETCH[1]

By D. J. HARBOU
SINDAL, DENMARK

On the sixth of January, 1884, the pioneer of genetical research, Gregor Mendel, died at Brünn, without having made his name generally known and without having received due acknowledgment of his scientific achievement. Yet so important was this work that Mendel will always rank among the great names of science.

To many people, Mendel and the history of his discovery are certainly not unknown, but the impression left by the general presentation is, in my opinion, not quite correct, and it is the object of this article to utilize the opportunity offered by the fiftieth anniversary of Mendel's death to direct the attention of the public a little more toward the man, Mendel, at the cost of the idea generally entertained of Mendel and his work.

As a matter of fact, it is well worth the trouble to become a little better acquainted with the personality and life of Mendel, for it is very rare indeed to find instances of a man being in such perfect harmony with his career and his life work. On the other hand, a consideration of Mendel's character will afford an entirely satisfactory explanation of his discovery and his fate in life. The most prominent features of Mendel's character were an almost obstinate perseverance in what he considered to be right, united with clear judgment, respect for truth and justice, faithfulness to persons and institutions to whom he owed gratitude, and finally a practical sense of reality.

Through the parish records the name and family of Mendel can be traced back to the seventeenth century. The name was originally spelled Mandel, and his ancestors were peasants of German origin, many of them Protestants. Johann Mendel (Gregor was his adopted name as an Augustinian monk) was born on July 20, 1822, in Heinzendorf near Odrau, a village in Austrian Silesia, now Czechoslovakia. He was the son of Anton Mendel and his wife Rosina, whose maiden name was Schwirtlich.

Mendel's father was originally a socager, but through ability and diligence he became an independent proprietor of a farm. His chief interest was the orchard, and the various tasks to be performed there were learned by his son, Johann, at an early age. Mendel's interest in horticulture can undoubtedly be traced back to his early childhood. His scholastic talents he himself attributed to his mother's family, for he was accustomed to say in jest, but not without a certain pride, that he descended from a pedagogic family. This allusion was to his uncle, Anton Schwirtlich, who founded a private school in Heinzendorf for children too young to go to the parish school in the neighboring village.

It will be seen that Mendel was born of a respectable though poor family. In fact, his was an excellent home, where the relations between the various members of the family were of the best and where no effort was spared to give the children every possible opportunity in life. A digression is here made to further show the excellent spirit of this family and also because of the insight it gives into the character of Mendel. In later years when the small family income

[1] Adapted for publication by Dr. Edwin R. Helwig, University of Pennsylvania.

GREGOR JOHANN MENDEL

did not suffice for keeping him at his studies a younger sister voluntarily gave up her marriage-portion, thereby making it possible for him to continue his studies until assistance could be obtained elsewhere, *i.e.*, from the Catholic Church. Mendel was only nineteen years old at this time, and knowing his character it can be said with certainty that he did not accept this sacrifice without a sense of responsibility. That he accepted it at all shows the strength of his desire to proceed with his studies, and it can be taken for granted that he determined to repay his debt. He actually did so by defraying the expenses for the education of his three nephews, each of whom took a university degree.

He obtained his earliest instruction in the village school of Heinzendorf, established after the death of Schwirtlich. The schoolmaster, perceiving Mendel's abilities, encouraged him in his studies, and this was further stimulated by two older boys who attended the advanced school in Leipzig and spent their vacations during these years in Mendel's home. He was then permitted to enter the advanced school in Leipzig. Two years later he went to the Gymnasium

at Troppau, where one of his teachers, who was an Augustinian, pointed out to his pupil how well scientific studies could be pursued amidst the tranquillity of a monastery. By 1841, when Mendel had passed his final examination with credit at the Gymnasium, his plans for the future were already formulated. He would take a course of philosophy at Olmütz and then apply for admission into the Augustinian order, which was well known to be a sanctuary for scientific studies. At Olmütz Mendel proved to be an excellent student, though illness forced him to repeat his course so that it was not until 1843 that his studies there were concluded.

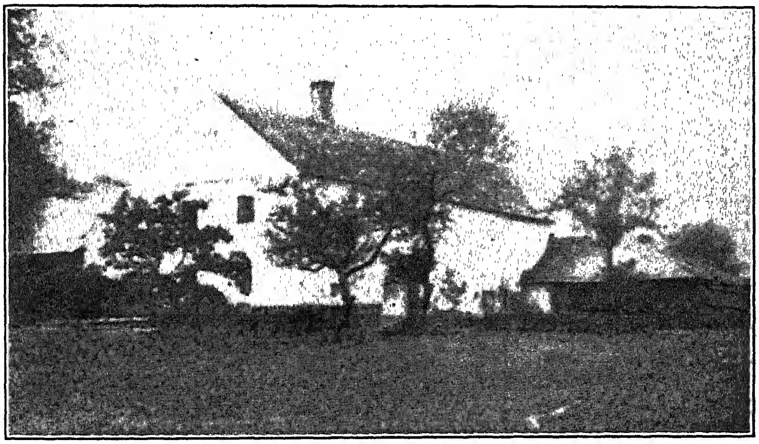
Mendel, equipped with the highest recommendations from his headmaster at Olmütz, applied for admission to "St. Thomas' Augustinian Foundation" in Brünn, the chief monastery of the order in this part of the country. The only handicap was that Mendel was not familiar with the Czech language, "which, however, he would undoubtedly quickly be able to learn." So, on October 9, 1843, Mendel entered the monastery as a novice.

The next three years were devoted exclusively to theological studies. On December 26, 1846, he took the solemn vow, adopting the name of Gregor. In 1847, he was ordained a priest and entered upon his duties as pastor of Alt-Brünn on July 26, 1848.

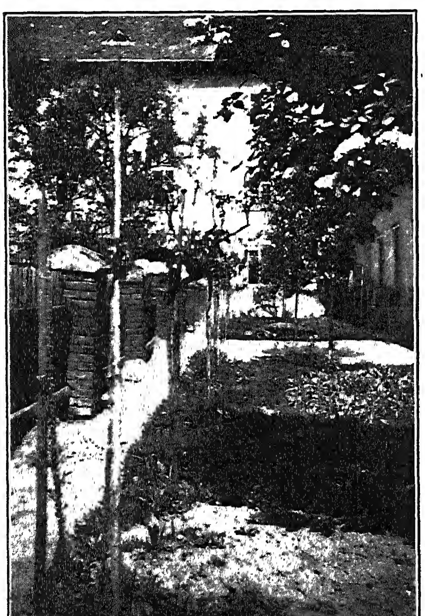
In 1849 Mendel went to Znaim as a deputy teacher of Greek and physics at the local gymnasium, but at the close of the summer term (1850) he returned to Brünn, where he taught natural history at the Brünn Technical School.

At length in 1851, when Mendel had entered his thirtieth year, his desire for scientific training in the natural sciences was realized. At the expense of the monastery he was sent to the University of Vienna, where he took a practical course in physical experiments and attended lectures on chemistry, zoology and botany. However, he endeavored primarily to acquire a knowledge of scientific working methods by frequent visits to museums and laboratories as well as through conversations with the scientists he met. Twice he attempted to take a scientific degree and both times failed.

This fact may cause some astonishment, and admirers of Mendel might be apt to seek the explanation in an unjust or too severe judgment of his work. However, his examination papers, provided with the commentaries of his cen-



MENDEL'S BIRTHPLACE



TWO VIEWS OF THE STRIP OF GROUND IN THE CONVENT GARDEN, WHERE MENDEL CARRIED ON HIS CLASSICAL EXPERIMENTS ON HYBRIDIZATION. THE OPEN WINDOW IS IN MENDEL'S ROOM.

sors, are still extant, and it appears that he had been judged fairly. He left the university without a degree but, as the future proved, with an excellent training and a knowledge of rational scientific methods.

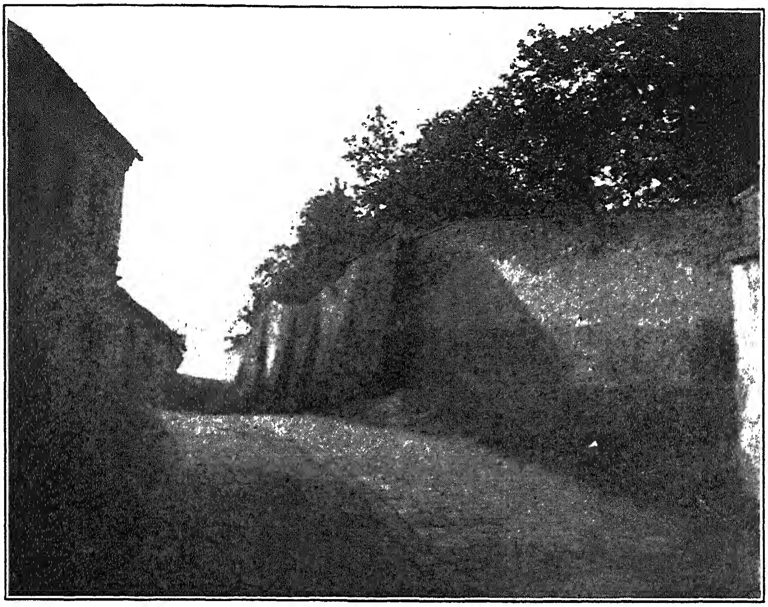
A short time after his return to Brünn, Mendel was appointed teacher of natural history in the Brünn Modern School. He filled this post for fourteen years, and it was during these years that Mendel performed his famous plant experiments in the garden of the monastery.

At this time the scientific world of Europe was particularly interested in an explanation of the extraordinary multiplicity of living forms. Darwin tried to solve the problem by applying to nature the results obtained by breeders through the selection of breeding animals, thereby arriving at the idea of a "natural selection." Others were seeking the answer by investigating whether "intermediate forms" might not appear as hybrids between closely related species. However, it was noticed that the hybrids "went back to the parental form," and consequently no positive results were obtained from this method of attack.

Mendel himself tried to produce permanent variations in this way. He cultivated two varieties of Ficaria side by side for several years without observing any alterations or new forms. Consequently, to Dr. von Niessl, a member of the Brünn Society for the Study of Natural Science, he said, "As far as I can see nature can not make any material progress in this way with regard to the formation of new species. *There must be something more behind.*"

That Mendel had a clearer understanding of his problem than had any of his predecessors is shown in the foreword of his classical publication, "Versuche über Pflanzen-Hybriden":

That it has not so far been possible to establish a universal law for the formation and development of hybrids no one, familiar with the extent of the problem and the difficulties with which experiments of this kind have to contend, can wonder. An entirely conclusive judgment of the question can not be given until detailed



THE WALL AROUND THE CONVENT GARDEN

experiments have been made on the most diversified families of plants. A careful consideration of the works hitherto undertaken will lead to the conclusion that so far none of the numerous experiments have been carried to such an extent or in such a way as to make possible a determination of the number of different forms in which the offspring of the hybrids appear or to arrange these forms with certainty within the different generations so as to ascertain their numerical relations.

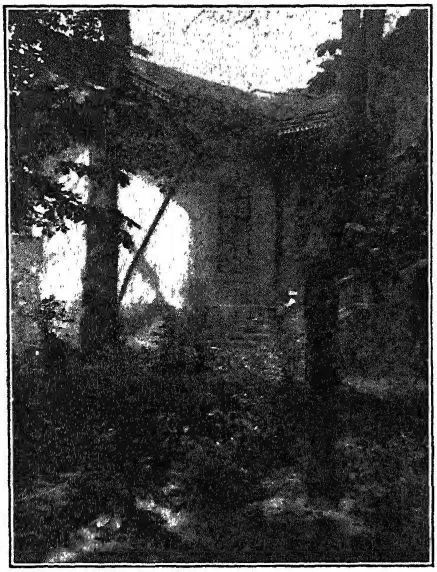
At any rate a great deal of courage is required to undertake such an extensive work. It seems, however, to be the only possible way to reach the solution of a question which is undoubtedly of no small importance in its bearing upon the evolutionary history of organic forms.

The present work describes the result of such a detailed experiment. It is deliberately limited to a small group of plants and is now, after eight years, practically concluded. Whether the plan upon which the individual experiments have been arranged and conducted is in harmony with the problem to be solved must be submitted to the kind judgment of the public.

Mendel's insight into his problem is further shown by his choice of the garden pea for his experiments. In doing this he acted on a thoroughly considered plan, not on any casual, ingenious inspiration. Mendel states that he selected this plant because the various sorts possessed constant and easily distinguishable characteristics; the technique of artificial fertilization was comparatively simple and gave reliable results, and the fertility of the hybrids and their offspring was not diminished by hybridization or self-fertilization through a series of generations.

The characteristic feature of Mendel's experiments, as compared with earlier experiments of a similar nature by other investigators, was that Mendel crossed very closely related plants, from which he could obtain hybrids of undiminished fertility, and that he dealt statistically with each pair of contrasting characters for several generations.

The results which Mendel submitted to the Brünn Society for the Study of Natural Science on February 8, 1864, laid the foundation for all subsequent work on heredity. Without detracting from the importance of Mendel's work, it can be said with certainty that he did



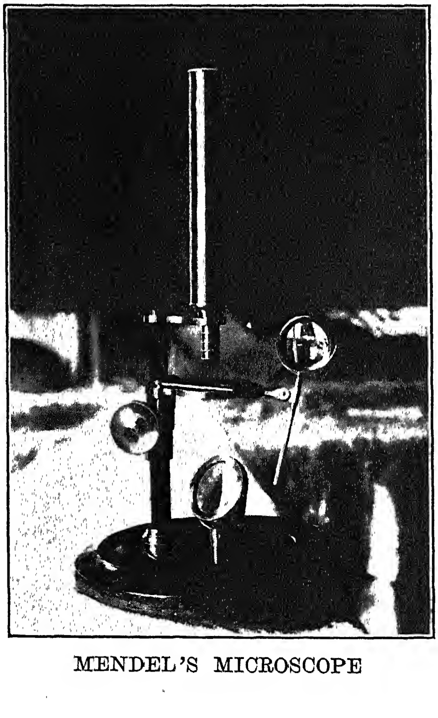
PAVILION
IN THE CONVENT GARDEN, WHERE MENDEL WORKED OUT THE RESULTS OF HIS EXPERIMENTS.

not aim at this goal. His object was to contribute to the solution of a problem of contemporary interest. With respect to this question—the origin of species—Mendel's results were, however, practically negligible. On his principles alone no general theory of evolution could be constructed, but as supplementary additions to Darwin's theory they might have profoundly influenced the development of the doctrine of evolution. Perhaps Darwin would have succeeded in effecting the synthesis between his own and Mendel's ideas that is happening only now, as a result of the last few decades of research. It is therefore much to be regretted that Darwin never became acquainted with the discoveries of Mendel.

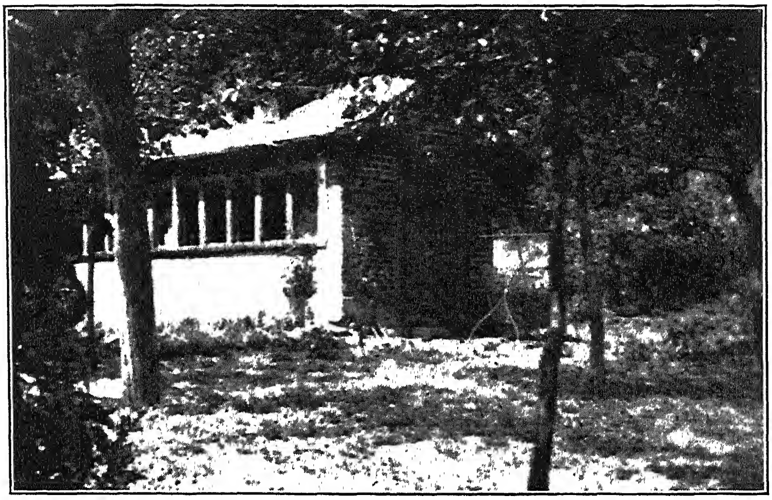
On the other hand, the work of Darwin indirectly exerted a fatal influence on the reception given to Mendel's discovery. Due to Darwin's brilliant combination of facts and theories the problem of the origin of species was regarded as solved. This circumstance is undoubtedly the chief reason why Mendel's work remained unheeded, although the "Proceedings of the Brünn Society for the Study of Natural Science" were exchanged with 120 scientific societies and two of the most remarkable biologists of the time, Anton Kerner and Carl von Nägeli, are known to have been familiar with it.

It was Nägeli who directed Mendel's attention to the hawkweeds (Hieracium) upon which he next experimented. In view of Mendel's object to contribute to the understanding of the origin of species Hieracium was a particularly interesting genus, owing to its richness in varieties. However, it was an unfortunate choice due to a peculiarity of the genus Hieracium to form seeds in some cases without preceding fertilization. This fact was unknown in Mendel's time, but he quite correctly observed that identical methods of fertilization produced different results in the first generation.[2] Considering the rarity of this

[2] Some of the offspring developed from fertilized eggs and some parthenogenetically.



MENDEL'S MICROSCOPE



MENDEL'S BEEHIVES

method of propagation among flowering plants, it was a misfortune that was well fitted to raise doubts as to the reliability of the previously published experiments on peas. Nevertheless, Mendel published these results, but added that the work had hardly gone beyond a beginning. He suppressed his doubts as to the expediency of publishing such unfinished results because a number of years would be required to complete the projected experiments and the uncertainty of his being able to finish them induced him to submit the work at this time (June 9, 1869).

It was Mendel's plan to extend his experiments into the animal kingdom and he selected bees probably for the practical reason that he was already well acquainted with their care. Mendel had about fifty hives under observation in the convent garden. He collected queens of all available races, European, Egyptian and American, and cross-bred these races. It would be of the greatest interest to know the results obtained by Mendel, but it has been impossible to find them, although it is known that Mendel kept notes on this work. Probably Mendel destroyed them during the mental depression with which his last days were afflicted.

Due to the demands of other work, Mendel gave up his plant experiments in 1870, two years after his election as prelate. However, he continued his experiments on bees and his meteorological researches until a short time before his death. His meteorological work was no less intensive than his breeding experiments, and it alone would have been able to secure him the position of a scientist of high standing, if not of universal renown. Mendel's purpose in these meteorological observations was founded on an idea in which he again was before his time. He tried to prove a correlation between the appearance of solar spots and weather conditions. To this end the height of the barometer, temperature, percentage of moisture and ozone in the air and the water level in the town well were recorded three times each day for thirty years. These notes, written with an almost incredible care and diligence, leave a strong impression of Mendel's industry, perseverance and fidelity to a task once undertaken. During his last years, he probably entertained no hope of seeing the results of this work him-

self, but nevertheless he only reluctantly gave up this duty, which was the last tie that connected him with his lifelong passion for scientific research.

During the years in which Mendel carried out his various experiments he also performed his duties as a priest and teacher, and as the years accumulated, his reputation as one of the most prominent and able citizens of Brünn continuously increased. He was elected to several posts of honor, but the most curious expression of his fellow-citizens' confidence was, however, the election of the priest and scientist as chief director of the Moravian Mortgage Bank, a position for which his profound knowledge of human nature, his common sense and integrity and, not least, his ability to deal with figures made him eminently fitted. His versatility and interest in problems of all kinds is evidenced by the fact that he is still remembered in Brünn as an excellent chess player.

It certainly did not cause any wonder when in 1868 Mendel was chosen abbot of the monastery. His qualities and talents marked him as one eminently fitted for the daily management and administration of the large property of the monastery. Mendel owed his convent too much to take a light view of the duties of this responsible position. It was the monastery which had admitted the impecunious young student, had made him financially independent and had defrayed the expenses of his university training. It had also hospitably opened its garden for his experiments and Mendel undoubtedly felt grateful for this opportunity to repay his debt of gratitude by a faithful performance of his manifold duties. Besides, he hoped, as is shown by a letter to Nägeli, to have better opportunities for performing the hybridization experiments which would lead to a final victory for his ideas.

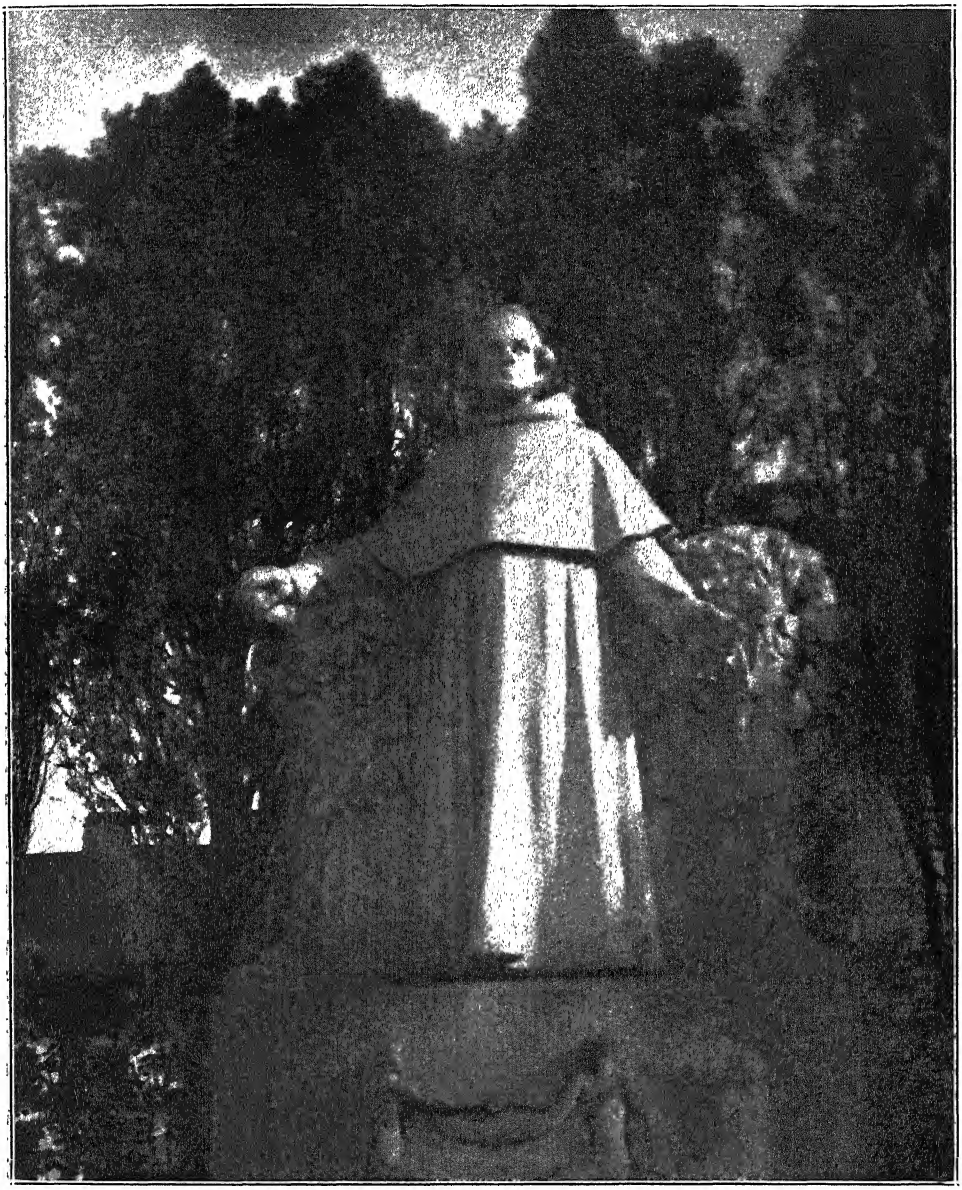
However, events decreed otherwise, for Mendel's time became occupied with his official duties. All Mendel's biographers agree in regretting this circumstance, a regret which is not, after all, quite reasonable. Had Mendel acted differently and, neglecting his official duties, continued his work in the experimental garden, science might have been enriched the more by an ingenious piece of work, but history would have lost one of its luminous examples.

A concurrent demand on Mendel's time was a conflict with the Austrian government, which deserves a more detailed mention, as it contributes greatly to our understanding of Mendel's character.

As my opinion of Mendel's conduct in this affair differs somewhat from that of earlier authors, I must consequently recapitulate the events on which my view is founded.

When the Pope in 1870 had proclaimed the doctrine of infallibility and declared himself the prisoner of Italy the German "Centrum" party requested the German Empire to reinstate the Pope in all his secular rights. Bismarck replied to the request of the "Centrum" by banishing the Jesuits from Germany, the "May Acts" of 1873 and the severance of diplomatic connection with the Vatican. A similar anti-Catholic movement simultaneously made itself felt in Austria which led to the Austrian "May Acts" of 1874, a body of laws in all respects certainly much more moderate than the German ones, but the tendency of which nevertheless was such that the Pope "ex cathedra" declared them null and void, now and in all eternity.

Among the "May Acts" was also the so-called "Religionsfondgesetz," according to which a fund for religious purposes was to be provided by imposing upon the rich benefices a comparatively heavy tax. The Augustinian monastery of Brünn had thus to pay an extra tax, amounting to about $8,000 a year. The



MENDEL'S MEMORIAL IN BRÜNN

Erected in 1910 through contributions from people of all nations. Executed by the Viennese sculptor Theodor Charlemont.

opponents of this law, among whom Mendel was one of the most active, maintained that the religious purposes aimed at were a question of general importance and not of special interest to religious institutions, which must be entitled, in this as in other respects, to equal treatment with all other taxpayers. This reasoning was logical, but the law was valid, having been passed by the "Reichstag" and sanctioned by the lawful government.

Mendel, however, on behalf of his monastery consistently refused to pay this tax. Eventually the property of the monastery was sequestrated and the income used partly for the payment of the tax, partly for the salaries of the administrators appointed by the government. Gradually the convents, which had made common cause with Mendel, were tired out by the rigorous measures of the government and only Mendel refused to give in, sending one protest after another for the government's consideration. Mendel's right and power to continue his policy were based on the fact that the infallible Pope had declared the May Acts invalid. As a man of common sense, Mendel could not fail to realize that the government had the means to collect the tax by force, so what did he expect to gain by his obstruction? In my opinion, his conduct can not be said to have been, as it is generally represented, a blind war against injustice carried on exclusively in the fanatic persuasion of having right on his side. Examples of Mendel's perseverance bordering on obstinacy have been seen but only where he was entitled to expect results. Mendel expected to obtain results by his perseverance, and subsequent events justified his expectations.[3] The first indication that Mendel was justified in expecting the government to "come to Canossa" was when in the middle of the conflict it offered Mendel the distinguished Leopold Order and a seat in the "Hirrenhaus" (senate). Mendel refused and continued the struggle.

The conflict, nevertheless, was telling on his health. His formerly cheerful and amiable disposition changed gradually into suspiciousness and misanthropy. Before the controversy was ended the chronic nephritis, from which he suffered during his last years, caused his death on January 6, 1884.

There is a trait of heroism in the best sense in the life of Gregor Johann Mendel, as shown by his early struggle against poverty to acquire knowledge and in the perseverance and enthusiasm with which he carried out his difficult experiments in spite of distractions and disappointments. Gregor Mendel died nameless as a scientist, his fame as such arising only after thirty-five years of oblivion. That Mendel himself was inwardly convinced of the importance of his work is seen from an utterance which he is said to have made frequently to his friends: "My time will come."[4]

[3] A few years after Mendel's death it proved that he had not fought in vain. Mendel's successor, through an adroit juridical treatment of the affair, managed to get refunded the money which the government had got "above what was due." Practically all that had been collected from the monastery was returned.

[4] Elsewhere he states that if the results of his pea experiments should prove to be universally valid "this would be of no small importance."

DETERMINING PARENTAGE

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THE difficulties of establishing paternity have been recognized from earliest times, as is indicated by the Roman law, "pater semper incertus." Similarly, according to the Talmud, no one is permitted to swear that he is a certain child's father; only the mother may swear, "This child is mine."

One of the oldest methods of determining parentage and one still employed in the law courts of some states, is by demonstrating the resemblance of the child to the putative father. Even photographs have been used as evidence. In most cases, only the general impression is depended upon, but at times, individual characteristics are emphasized, as in the following passage from Shakespeare's "Winter's Tale" (II, 3):

Paulina: It is yours;
And might we lay the old proverb to your charge,
So like you, 'tis the worse.—Behold, my lords,
Although the print be little, the whole matter
And copy of the father,—eye, nose, lip,
The trick of his frown, his forehead; nay the valley,
The pretty dimples of his chin and cheek, his smiles,
The very mould and frame of hand, nail, finger:—
And thou, good goddess Nature, which hast made it
So like to him that got it, if thou hast
The ordering of the mind too, 'mongst all colours
No yellow in't; lest she suspect, as he does,
Her children not her husband's!

This appeal, in which Paulina tries to convince Leontes that his wife, Hermione, has been faithful to him and that the child born to Hermione is his own, closely resembles some of the speeches made by lawyers to juries in law courts. In this connection, it is of interest to cite a bastardy case tried in the Court of Quarter Sessions of Fayette County, Pennsylvania, in 1931. In this case an Italian man was said to be the father of the illegitimate child of a white woman, but according to blood tests performed by Dr. Heise it was impossible for the accused man to be the father. Nevertheless, since the jury was convinced by the district attorney that the child in question showed some resemblance to the accused man's *father,* they returned a verdict of "Guilty."

It is well known that though close blood relatives frequently resemble one another, it is not uncommon for total strangers to exhibit similar characteristics. Furthermore, since the features are continually changing, especially in the transition from childhood to maturity, to judge resemblance of infants is highly unreliable. For this reason, in certain states, *e.g.,* New York State, the law does not permit the exhibition of the child to the jury for purposes of proving paternity. And in Shakespeare's play, cited above, Leontes was not convinced by Paulina's arguments that Hermione's child was his. However, as late as 1931, a jury in Pennsylvania allowed itself to be convinced by such arguments and entirely overlooked scientific proof by blood tests of the accused man's innocence. Fortunately, the judge did not allow himself to be deceived, and finding the verdict to be against the evidence, he declared a mistrial. The woman never applied for a new trial, since shortly afterwards the infant's features began to change, and now,

three years after the trial, the child has features definitely Negro in character.

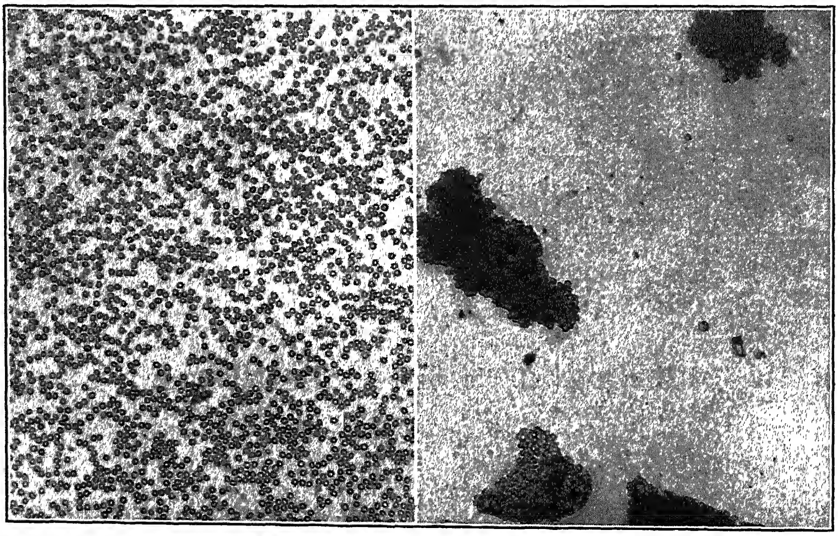
At any rate it is fortunate that the courts do not pursue this belief to such an extreme as, according to Strabo, was done in Carthage, where the children, when they reached the age of two months, had to be examined by a special committee, and if their resemblance to the father was not great enough, they were killed.

That attempts were made to devise other methods of determining paternity is not surprising. The ancients attributed certain mystic powers to the blood, and such beliefs have survived to the present day in sayings such as "blood will tell" and "blood is the base of all." As interesting examples of such superstitions, the following methods of detecting blood relationship are cited from Chinese and Japanese books of the thirteenth century:

A drop of blood is obtained from each of the two supposedly related individuals by pricking their fingers; and the two drops of blood are allowed to fall into some water. If the two persons are blood relatives, the bloods will flow together. Or, in the event that the mother or father is dead, the blood of the supposed son or daughter is allowed to fall on one of the bones of the dead parent's skeleton. Only if the blood penetrates the bone, so that it cannot be washed off, is the existence of a true blood relationship established.

In Bosnia, recently married young men use a sort of "God's judgment" when the child is born before the end of the ninth month. The husband places the child on the threshold; if it falls into the house, then it is surely his, but if the child falls out of the house, the husband disowns it.

The judgment of Solomon is often cited as an illustration of God-sent wisdom. His conclusion was but natural, and nowadays King Solomon would merely be called a clever psychologist. Interestingly enough, the newspapers recently contained the report of a modern counterpart of this case. Each of two women claimed that a certain child



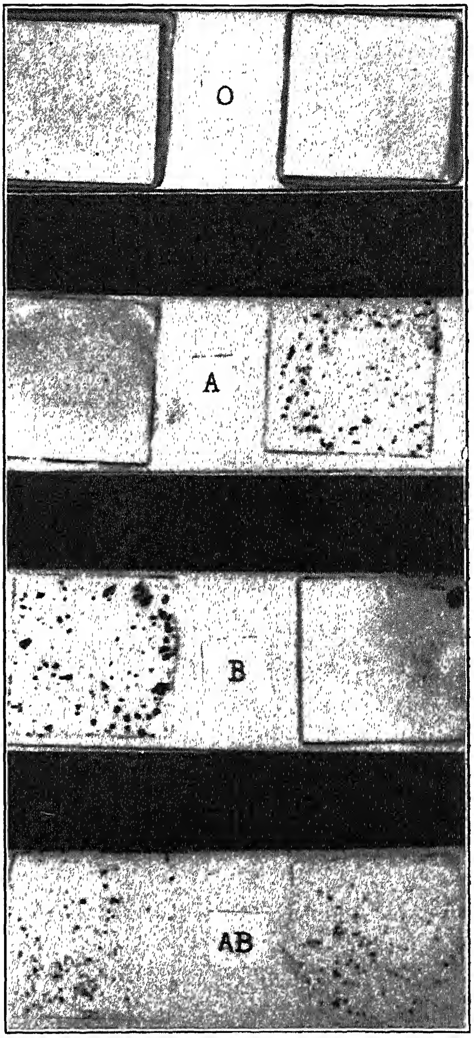
MICROSCOPIC APPEARANCE OF THE AGGLUTINATION TESTS

Left: NEGATIVE REACTION—EACH RED BLOOD CELL IS SEPARATE AND DISTINCT. *Right:* POSITIVE REACTION—THE RED BLOOD CELLS ARE AGGLUTINATED TOGETHER IN LARGE CLUMPS. (MAGNIFICATION 1: 80.)

was her own, and the judge stated that since he had no way of determining to whom the child belonged, he would settle the case by sending it to an institution. One of the claimants expressed satisfaction with this decision, since she would prefer to have the child sent away than given to the other woman; the second claimant stated, however, that she would rather give up the child to the first woman than have it sent to an institution, where it would be deprived of a mother's love and care. The child was then awarded to the second woman.

A more scientific method of establishing parentage is based on the fact that when certain rare abnormalities are present in one or both of the parents, they frequently reappear in some or all of the children. The remarkable accuracy of the heredity of some of the digital malformations is illustrated by a paternity case reported by Mohr (1921). The father had a pronounced shortening of the fingers and toes 2, 3 and 4, caused by incomplete development of the second row of phalanges. The thumbs were normal, but the basal phalanx of the great toe was shortened. Since the hands and feet of the child showed the identical malformation, the man was adjudged the father.

Inasmuch as certain abnormalities are inherited as "recessives" they may appear in children both of whose parents are apparently normal. Until comparatively recent times, the appearance of such monstrosities was attributed to certain experiences of the mother during her pregnancy. The belief that if the pregnant woman should see an ugly or terrifying object, it will be reproduced in the child dates from the remotest antiquity. Novelists (Goethe, Shakespeare, Dickens, etc.) have used this idea as a favorite theme, and many names great in the history of medicine could even be quoted in its support. In a novel by Arthur Schnitzler, a certain woman from a small town gives birth to a Negro child following a visit to a



BLOOD GROUPING ON GLASS SLIDES

Actual size. The tests were performed by mixing one drop of the unknown cell suspension with one drop of group A serum (left), and one drop of cell suspension with one drop of group B serum (right). A positive reaction is recognized by the appearance of brick-red granules, due to the clumping together of the blood cells, whereas in a negative reaction the blood suspension is unaffected and apppears homogenous to the naked eye. Group O blood does not react with either serum, group A blood reacts only with group B serum, group B blood only with group A serum, and group AB blood reacts with both sera.

Negro troupe in Vienna. The husband, who has complete faith in his wife's fidelity, is convinced that this is a case of "maternal impressions" and collects numerous examples of this phenomenon out of the literature. In Shakespeare's play "Titus Andronicus," however, when Tamora gives birth to a colored infant, she tries to do away with it, since she knows that her husband will not be deceived so easily by "pseudoscientific arguments." Thomsen has recently reported a case tried in Denmark, in which the illegitimate child of a servant girl possessed an unusual deformity of the fingers that corresponded exactly to that of the mother's employer. The claim for maintenance for the child was refused by the court, however, since it was held that the continual observance by the mother of her master's deformity fully accounted for the appearance of the anomaly in her child. This illustrates how difficult it is to destroy popular belief in certain superstitions, even in the absence of any rational basis.

Blood Tests and Paternity

The problem of determining parentage has not been entirely solved yet, but recently methods have been discovered, based on well-established scientific facts, which make it possible to render definite decisions in a certain percentage of cases. These methods are an outgrowth from a relatively new branch of medicine, namely, serology.

The blood is made up of two main fractions, the red cells, which give the blood its color, and a fluid called the plasma (or serum[1]). In the human red blood cells there are two substances called agglutinogens A and B. If an individual possesses both these substances in his blood cells, he is said to belong to group AB, if neither, he belongs to group O; if he possesses only A, to group A; and if only B, he belongs to group B. In the serum are two substances, called agglutinins, α (or anti-A) and β (or anti-B). If a serum containing agglutinin α is mixed with red blood cells containing the agglutinogen A (group A or group AB), these cells will be clumped together (or agglutinated) or may be entirely destroyed. On the other hand, such a serum would not affect red blood cells not containing A (of group O or group B). Similarly, agglutinin β acts on bloods of group B and group AB, but not on bloods of group O or group A. Naturally, an individual of group A can not have agglutinin α in his serum; and neither can a group B individual possess agglutinin β. The constitution of the four blood groups and their approximate frequencies in New York City are as follows:

Group	Frequency (Per cent.)	Red Blood Cells (Agglutinogen)	Serum (Agglutinin)
O	40	—	α and β
A	40	A	β
B	15	B	α
AB	5	A and B	—

The technique of the tests is very simple. All that is required is a suspension of the red blood cells of the individual to be tested, which is prepared by mixing a few drops of blood from the finger with isotonic salt solution. Two sorts of testing sera are used, one containing agglutinin β alone (group A), the other agglutinin α alone (group B). These sera are obtained from normal individuals by collecting blood which is allowed to clot. After the clot contracts, the clear yellow serum can be separated. The actual tests are performed by mixing a drop of cell suspension with one drop of each of the two testing sera. If the cells are agglutinated by both sera, the individual being tested belongs to group AB; if by neither, to group O; if

[1] The fluid remaining after coagulation of the plasma is the serum.

only by group B serum, to group A; and if only by group A serum, to group B. The difference between a positive and a negative reaction is shown in the two illustrations.

The human blood groups, described above, were discovered in 1900 by Dr. Karl Landsteiner, of the Rockefeller Institute, who was also the first to suggest the application of the discovery to blood transfusion. It may be of interest to point out, in passing, the significance of this aspect of blood grouping. In the very first blood transfusions performed on man the blood of animals, especially the lamb, was used (Denys, 1667). This procedure was frequently followed by fatal reactions, which were finally explained by the discovery that animal sera agglutinate or destroy human red blood cells, and human serum agglutinates the blood cells of lower animals (Landois, 1875). Attempts were then made to perform transfusions using human blood, but even then fatal reactions continued to occur. This was puzzling, since it was assumed that the bloods of individuals of the same species must be identical, but the mystery was solved when Landsteiner discovered the existence of the human blood groups. At present, blood transfusions can be safely performed by selecting a donor belonging to the same group as the recipient, and, in New York City alone, 10,000 transfusions are performed every year, so that the discovery of the blood groups is responsible for the saving of thousands of lives.

To return to the subject of this paper, the medicolegal application of blood grouping for the exclusion of paternity depends upon the following three important properties of the blood groups: (1) The blood group of any individual can be determined at birth or shortly thereafter; (2) the blood group of every individual remains constant throughout life and does not change regardless of age, disease, medication, etc.; (3) the blood groups are inherited in accordance with Mendel's laws.

That the blood groups are inherited has been known since 1910, when, after a preliminary study by Ottenberg and Epstein, von Dungern and Hirszfeld found in an investigation on 72 families with 102 children that the agglutinogens A and B never appear in the blood of a child unless present in the blood of one or both parents. This rule has been corroborated by many other independent investigators on tens of thousands of families. The results of these studies make it possible to predict what the groups of the children must be if the groups of the parents are known, as is shown in matings 1 to 6 in Table 1.

TABLE 1

THE LANDSTEINER BLOOD GROUPS IN PARENTS AND CHILDREN (BERNSTEIN THEORY)

Groups of parents	Groups of children possible	Groups of children not possible
1. O ×O	O	A, B, AB
2. O ×A	O, A	B, AB
3. O ×B	O, B	A, AB
4. A ×A	O, A	B, AB
5. A ×B	O, A, B, AB	———
6. B ×B	O, B	A, AB
7. O ×AB	A, B	O, AB
8. A ×AB	A, B, AB	O
9. B ×AB	A, B, AB	O
10. AB×AB	A, B, AB	O

In interpreting their results, von Dungern and Hirszfeld postulated that the agglutinogens A and B were inherited independently of one another. By making certain statistical calculations, however, Bernstein (1925) was able to prove that this assumption was incorrect and that actually the heredity of the blood groups depends upon three allelomorphic genes, A, B and R. This newer development does not affect the law discovered by von Dungern and Hirszfeld, since according to Bernstein's theory

also it is impossible for the agglutinogens A and B to appear in the child's blood unless present in the blood of one or both parents. In addition, however, according to the theory of three allelomorphic genes, a group AB parent can not give rise to a group O child, and a group O parent can not have a group AB child. These additional exclusions are listed in matings 7 to 10 of the table.

How this knowledge can be applied is best illustrated by citing an actual case. In a recent case tried in the Court of Common Pleas of New Haven County, a woman falsely accused a man of the paternity of her illegitimate child. Although the defendant repeatedly denied his guilt, the weight of public opinion was against him. The bloods were sent to the present author for examination, and it was found that the man belonged to group A, the woman to group O and the child to group B. Since the child possessed the agglutinogen B not present in its mother's blood, the true father could only belong either to group B or group AB. Confronted with this evidence, the woman withdrew her charge and the man was acquitted. In this case, therefore, the blood tests prevented a miscarriage of justice.

Suppose, however, that it had been found that the accused man belonged to group B or group AB. This would not prove that he was the true father any more than another man belonging to either of these groups. In such an event, the blood tests would be of no avail. In general, therefore, blood grouping can be used only to *exclude,* not to *prove* paternity. If it is known, however, as is sometimes the case, that one of two men is the father of a child, if one of the men can be excluded by the blood tests, it follows that the other must be the father of the child.

In 1930 there was an interesting case in Chicago, which illustrates another application of the Landsteiner blood tests. In this case, the problem of identifying two newborn infants which had been interchanged in the hospital was solved by blood grouping. One week after taking their baby home, Mr. and Mrs. B. discovered that the baby had a label on its back with the name "W.". At the W. home the baby was found to bear the label "B." All six individuals were then grouped, with the following results:

Mr. B.	group AB	Mr. W.	group O
Mrs. B.	group O	Mrs. W.	group O
Baby bearing label "W."	group O	Baby bearing label "B."....	group A

Since a group A child can not occur in the W. family, but may occur in the B. family (see Table 1); and since a group O child can not occur in the B. family but is possible for the W. family, it was evident that the babies were properly labeled but had been taken to the wrong house.

As is seen from Table 1, only with certain combinations of the blood groups of the mother and child is a decision possible. Thus, in one sixth of the cases where false accusations are made, blood grouping can establish a man's innocence. Until recently nothing could be done about the remainder of the cases. In 1927, however, Landsteiner and Levine discovered two additional agglutinogens, M and N, in human red blood cells. These agglutinogens had not been previously observed because normal human or animal sera do not contain agglutinins against M and N. However, by injecting human blood into rabbits or other animals, such as cats and goats, sera may be obtained with agglutinins for M and N. The agglutinogens M and N are entirely independent of the agglutinogens A and B and define three distinct types of human blood as follows: Type M (blood possessing only agglutinogen M)—this type makes up approximately 30 per cent. of the general population; Type N (blood possessing only agglutinogen N)—20 per cent.;

Type MN (blood possessing both agglutinogens, M and N)—50 per cent. No individuals have been found whose blood lacks both agglutinogens M and N in more than 30,000 tests made to date.

In 1928, Landsteiner and Levine showed that the MN-types are also inherited according to Mendel's law. The theory of heredity they proposed has been confirmed by studies by many independent investigators on several thousand families so that the medicolegal application of the MN type is entirely reliable at present. The mechanism of heredity of the agglutinogens M and N is given in Table 2. This table is summarized in the following two laws: (1) The agglutinogens M and N can not appear in the blood of a child unless present in the blood of one or both parents; (2) a type M parent can not give rise to a type N child, and a type N parent can not have a type M child.

TABLE 2

THE AGGLUTINOGENS M AND N IN PARENTS AND CHILDREN

Types of parents	Types of children possible	Types of children not possible
1. MN × MN	M, N, and MN	—
2. MN × N	N and MN	M
3. MN × M	M and MN	N
4. M × N	MN	M and N
5. N × N	N	M and MN
6. M × M	M	N and MN

A few cases will be cited which illustrate the practical application of the MN-types in cases of disputed paternity:

In one case the question arose whether the husband or another man was the father of a child. The husband was willing to support the child, regardless of its paternity, but the wife insisted she would live only with the child's true father. Since both men belonged to group A, no decision could be made on the basis of the classic blood groups. When the bloods were tested for the properties M and N, however, the lover could be definitely excluded, since he belonged to type M, whereas the child belonged to type N. Of the two men, therefore, only the husband could be the father of the child. The complete results of the blood examinations were:

BLOOD OF	GROUP	TYPE
Husband	A	M
Lover	A	N
Wife	B	M
Child	A	M

As frequently occurs when attempts are made to make useful application of scientific knowledge, the blood tests in this case failed to produce the anticipated beneficial result, since the woman finally elected to go off with the lover.

In the second case, the problem of determining the paternity of three children arose. Without going into the details of the story, the results of blood tests may be summarized as follows:

BLOOD OF	GROUP	TYPE
Husband	O	MN
Lover	A	N
Wife	O	MN
First Child	O	MN
Second Child	O	M
Third Child	A	N

Since two parents belonging to group O can only have group O children, the third child, belonging to group A, could not be the husband's, but it could be the lover's. With regard to the other two children, no definite statement can be made on the basis of the blood groups, since either man could have group O children with a woman of group O (see Table 1). The tests for M and N yielded further information, since the second child, belonging to type M, could not have a type N parent. This child, therefore, could not be the lover's but could

be the husband's. No definite statement can be made about the first child, since either man could have type MN children with a woman of type MN (Table 2). In this case, therefore, the paternity of two out of three children was determined by the combined use of all four agglutinogens A, B, M and N.

It has been calculated that if both methods are used, a falsely accused man has one chance in three of exonerating himself by the blood tests. Fully 7 out of 10 cases of interchange of infants, such as the Chicago case described above, can be solved by the tests.

Paternity and the Law

The Landsteiner blood tests have been applied in cases of disputed paternity since 1924 in Europe. Some of the countries in which the tests are being applied are Austria, Germany, Denmark, Italy, Sweden, etc. As early as 1929, Schiff was able to compile statistics on over 5,000 European cases in which the tests had been used, and this figure has probably increased considerably by the present time. In this country, on the other hand, aside from isolated instances in Connecticut, Ohio, Illinois and Pennsylvania, the method has not been applied. Although a highly conservative attitude is indeed desirable when applying new scientific discoveries in legal procedures, still the blood tests for excluding paternity have passed well beyond the experimental stage, so that our courts would do well to follow the precedent set in European countries.

It is of interest to discern the attitude of our courts when confronted with the problem of legitimacy. According to existing laws in this country, any child born in lawful wedlock is considered to be legitimate. From the earliest days of the law, this presumption, which is given in the old Roman law "pater est quem nuptiae demonstrant," has been extremely difficult to overcome. At one time the law's attempt to protect the child's good name went to absurd degrees, as may be gathered from the rule of the "Four Seas" in England. On the basis of this law, one court decreed that a child born in England was legitimate, even though the husband resided in Ireland during the whole term of his wife's pregnancy and for a long time previously, because Ireland was within the King's domain. This absurd rule was modified in 1807, and to-day the presumption of legitimacy, though difficult to overcome, may be cleared by adequate proof in this country.

A brief review of some of the methods used in our courts to prove or disprove parentage will serve to emphasize the value of the blood-grouping tests:

Duration of Pregnancy. By duration of pregnancy is meant the interval in days between the time of impregnation and the beginning of labor. The average duration of pregnancy is stated to be approximately ten lunar months or 280 days, but there have been live "premature" births as early as 215 days and "postmature" births as late as 330 days. In some countries, the legally acceptable limits of the duration of pregnancy are fixed by law. In France, for example, legitimacy of a child born 300 days after the dissolution of a marriage may be contested. In American and English courts a more conservative attitude is adopted, since every case is judged on its own merits.

The main shortcoming of this criterion of legitimacy is that it can be practically applied in only rare instances, in contrast to the blood-grouping method which may be used in every case. Furthermore, in most cases where one attempts to use this evidence, there is a conflict in the testimony of the mother and putative father as to the date of intercourse. Thus, in a case recently tried in a New York court, a man sought

an annulment of his marriage, since his wife gave birth to a child only five months after their wedding. He denied having had intercourse with his wife before marriage, but she contended that there had been such relations. In order to protect the interests of the child, the testimony of the wife was accepted and the application for annulment denied. Possibly this case would have been solved by blood tests.

Impotence and Sterility. Sterility refers to the inability to procreate, whereas impotence refers to the physical inability to perform the sex act. While there is frequently impotence without sterility, the incapacity usually involves both functions simultaneously.

This entire subject is fraught with exceptions and doubts, since it is difficult to establish with certainty the complete absence of live spermatozoa. The mere fact that intercourse is difficult or unsatisfactory does not necessarily establish sterility.

The fallacy of attempting to establish paternity by resemblance has already been pointed out. Of no greater merit is evidence based upon the presence of the same venereal disease in mother, man and child, since there is a strong possibility of coincidence.

From the foregoing discussion, it is evident that the introduction of the blood-grouping tests would be a valuable aid to our courts in cases of disputed paternity. In a recent case in the Supreme Court of New York, a man was accused of the paternity of an illegitimate child, and the mother of the child sued him for civil damages. In a splendid opinion, Justice Steinbrink ordered blood tests, since the man in question denied paternity or ever having had relations with the woman. The woman refused to submit to the tests, however, and appealed from Justice Steinbrink's order. The Appellate Division reversed the decision on the grounds that there was no statutory authority for such an order, and that the tests were not in the child's interest and were a violation of its rights. If the Appellate Division implied by this that anything the mother does for the child, even if it involves making false accusation, is to be looked upon with approval, it is setting a very dangerous precedent.

Under the existing laws, if testimony concerning the blood groups of the individuals in a case of disputed paternity is available, it is admissible as evidence. The main difficulty is in getting the individuals involved to consent to the tests. In Germany many courts have adopted the policy that refusal of the woman to submit to the tests is presumptive evidence of the falsity of her accusation. In this country, however, such a procedure is not permissible. It would be helpful if laws will be passed empowering the courts to order individuals to submit to blood tests where they are material, in those jurisdictions where blood tests are not compulsory at present.

WINTER INJURIES AMONG TREES AND SHRUBS

By JOHN G. JACK

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Injuries to trees and shrubs and other vegetation in the winter of 1934 were so pronounced that it seems worth while to give some of the particular facts concerning the damages caused by temperatures and other climatic conditions which were so unusual that they affected many plants which we had heretofore regarded as hardy in our plantations. The records of the Weather Bureau do not show more severe and long-continued cold for the region which surrounds Boston, the record being applicable to a large proportion of the northeastern United States. Records of more than 30 degrees below zero, of Fahrenheit, were noted in some sections in eastern Massachusetts, and low temperatures of 15 to 30 degrees below occurred about Boston at the end of December, and registerings of from zero to 20 degrees below were almost continuous during the first two weeks of February. The cold was sometimes accompanied by severe winds. The intensity of cold varied much in different localities within a mile or two. Long, thin cracks developed in the trunks of old trees which had endured our winters for a century or more.

The Arnold Arboretum is commonly looked upon as more or less of a testing station of the hardiness or endurance of many of the woody plants which have been introduced from other parts within the temperate zones of the globe. Yet no safe estimate can be made of the probable behavior of any plant when judged by latitude alone. Many other factors must be considered. In addition to latitude and altitude and other ecological conditions, plants may prove satisfactory or useless for particular purposes, according to whether they were originally collected on the northern or southern or eastern or western side of a mountain or mountain range. In such cases temperature and rainfall or snowfall may be the dominant features affecting the endurance of plants when removed from their natural homes and brought into cultivation and under new environment. The amount and season of rainfall, proximity to the sea and the ocean currents, clouds, fogs, prevailing winds, soil, drainage, fertility of the ground and other conditions are factors likely to have a bearing upon the results of our labors.

In cultivation the careful and painstaking grower of exotic plants, which it is hoped may be naturalized or acclimated, wisely tries to imitate so far as practicable the best native or natural conditions, if known, of the introduced plants with which he has to deal. Upon the proper placing, the soil, drainage and moderate protection, success or failure may follow. Occasionally we have exceptional or catastrophic conditions, such as the very unusual and prolonged low temperatures during the past winter of 1934, when most ordinary precautions fail to prevent serious damage to plants ordinarily hardy.

The reason why, under unusually severe conditions, plants of a certain species may survive in good order in one part of a yard or garden, while failing in another, may not be possible to determine with any certainty. Intensity of sunlight with rapid alternate freezings and thawings, winds or draughts of cold air on different sides of a house, or in different parts of a yard may cause a marked difference in behavior in plants

of the same origin. Trouble may be due to weakness of an individual. A few shovelsful of soil differing in composition from that given adjacent plants may have some effect. Injury may follow poor drainage. The application of too much manure or fertilizer too late in the season and late cultivation of the soil, thereby inducing late growth and the production of vigorous stems or shoots which do not ripen fully before autumn cold ends growth for the season, are factors which deserve attention. Such poorly ripened wood may pass through a mild winter without apparent injury, but if subjected to such unusually severe tests as in the past year it is very likely to be destroyed. Plants which fruited heavily the previous season may be weakened and so be rendered especially susceptible to unusually adverse conditions.

In cultivation trees or shrubs of a known or suspected tender nature should generally be well protected, if young, for two or three years after planting out, so that the root system may become well extended and adjusted to the surroundings. They should be planted on well-drained soil, preferably on rising ground or on the tops of slight ridges or knolls rather than in depressions or low areas surrounded by raised ground. While plants which have proved hardy may not be affected on low situations, the more tender sorts should do better on slopes well above depressions or areas surrounded by walls or thick growths of trees and shrubs. The coldest air settles in such "pockets" and may not have any easy "air flow" outlet. Those areas which have a good air current or flow from a superior elevation may have frost immunity for perhaps two or three weeks longer in spring and autumn than ground which is low-lying and where the air is comparatively still. This is important when considering the blooming season in flower gardens.

In connection with the question of hardiness there is often much confusion in the mind of planters and plant purchasers concerning the source of their trees and shrubs. Outside of a particular region, where a species may be native, the idea is prevalent that an ordinarily hardy plant may prove less so if purchased from a southern nursery, even if that nursery originally procured its stock from a northern nursery or a northern region where the species was indigenous. From our present knowledge that idea is erroneous. Millions of trees and shrubs, budded or grafted, or cuttings, are annually grown in our southern states, where labor is cheap and growing season long, and shipped to northern nurseries to be resold to the public. The propagation of different kinds of the common peach may be cited as an example. A native of temperate parts of China, the various forms appear to retain their hardiness whether grown in a warm temperate zone, as our southern states, or in the cooler northern parts of our country, excepting extreme portions where temperatures commonly fall to 15 or 20 or more degrees below zero of Fahrenheit. On the other hand, certain species of trees and shrubs, which are native only to our southern states, or similar regions abroad, are not rendered more hardy by growing or propagation in a northern nursery. There is something constitutional in the species which apparently resists all such temporary changes, although improvements may be developed by selection through generations raised from seed. However, the stocks used in propagation, besides the grafts or buds or other parts of the plant to be divided or increased, may prove a decided factor in regard to the question of hardiness. For example, if a crabapple which was known to be perfectly hardy in the North should be propagated in the South by grafting, and the grafting stocks chosen there were of a more tender character than the scions, the plants might not prove hardy when re-

turned to the North because the roots of the stocks might be winter killed and this would be fatal for the grafts. This experience has been carefully noted and guarded against by experimenters and orchardists in our rigorous northwest. Of course propagation by cuttings from an individual, where no foreign element like stock intervenes, is not affected. This is also true of seeds, but among seedlings some individuals may prove to be more robust than others and these may be selected and propagated by the hand of man. In grafting or budding it was formerly considered that the stock had little influence upon the scion, but recent experiments have shown that the grafts or scions may really be more affected than was formerly supposed.

The winter injury to our trees and shrubs may manifest itself in various ways. In extreme cases the whole plant, including the roots, dies and fails to put forth leaves in the spring. Very often it is killed to or near the ground, leaving a living base to develop new shoots if the plant is a shrub, as shown in many forsythias, or basal branches or sprouts may sometimes be trained to form new tree stems, as we expect from the Davidia. Again the damage may so affect portions of the bark of main limbs or trunks of trees that the bark may be separated from the wood or the inner bark becomes brown and dry, thus checking the normal flow of sap. In such cases leaves and flowers and a stunted growth may develop on parts of the tree in spring, but soon after these demonstrations of activity further growth is checked, the leaves and flowers wilt and the plant, or a large portion of it, is soon practically dead.

The famous Davidia or Dove Tree, of China, in the Arboretum seemed to show life in some branches as spring advanced, but it was only a feeble attempt at recovery and within a few weeks the trees were dead to the ground. The trees were 15 to 20 feet high. Although flower buds had been hurt or killed in some previous winters they had not shown other injury.

During the past winter many cherry, apple and other trees showed the bark killed on the sunny southwestern side of the trunks or the upper, sun-exposed sides of large limbs, the shaded side remaining sound. Fruiting bodies of fungi have developed during the summer, indicating rapid decay. The damages on such areas were probably caused by rapid freezings and thawings, perhaps supplemented by coatings of ice. Many shrubs showed a mixture of dead and living branches requiring careful pruning. It is common knowledge that in many of our cold seasons the dormant flower buds of some trees and shrubs, like peaches, almonds, sweet cherries, some hazels, and numerous others, may be killed by the cold and be flowerless in spring while the hardier leaf buds survive and produce a profusion of foliage.

In all cases of winter killing the snow line during the severest part of the season is important. A great many of the smaller shrubs may not be damaged because of protection afforded by snow, and the branches very near the ground on larger shrubs or trees may remain green and fresh and produce foliage or flowers when the rest of the plant may appear in a dead or dying condition.

In recent numbers of the *Bulletin of Popular Information,* issued by the Arboretum, lists have been given of a large number of species of deciduous shrubs and trees which were killed or injured by the unusually severe winter of 1934.

The yew and the conifer families suffered much from the cold, although on the whole the damage was less than the injury to many of our broad-leaved, deciduous trees and shrubs. Of some species the flower buds, or most of them, were destroyed. In some instances the buds which should ordinarily develop into new shoots or twigs were so greatly injured that they have failed to make

normal growth, so that affected trees will probably lose many of their branches and much of their symmetry, or they may die. While the Japanese Yew, *Taxus cuspidata,* generally passed safely through the winter there were plants of this species which showed some injury. This often took the form of arrested development of the terminal buds and shoots. These sometimes showed a browning of leaves. Generally the dormant buds started and a checked and irregular growth developed as the season advanced. The European or English Yew, *Taxus baccata,* suffered severely in some instances. Occasionally branches were killed or tips of branches failed to show life and some pruning became necessary. A careful inspection of such injured branches in midsummer showed very small latent buds developing in the axils of leaves or leaf scars. These in another year should develop into good normal shoots or branches. It should be noted that some of the plants which have been named as hybrids between the Japanese and European yews have shown less hardiness than the Japanese parent, though hardier than *Taxus baccata.* Some plants of the hybrid *T. media* show some injury on tips of branches, while *T. media hatfieldii* was much more seriously hurt.

After growing in the Arboretum for many years, during which it flowered and fruited, the Japanese *Torreya nucifera* was nearly killed but, although the terminal parts of the branches failed to recover, new shoots developed on the basal portions so that there is a prospect of the trees regaining a green aspect and good form after several years.

Among the conifers the pines as a group suffered less than some other genera. Some browning of the foliage occurred, but twigs and buds usually developed a full quota of leaves which covered many defects. Individuals of the same species varied much in their resistance to damage. Injuries to flower buds were noted in some foreign species.

On the whole the hardy native American spruces (Picea) wintered well. The fine Sitka Spruce, *Picea sitchensis,* can not be grown here, but the very rare Brewer or Weeping Spruce, *Picea breweriana,* of the mountains of southern Oregon and northern California, will live but does not thrive. The single plant, now 7 feet high, in the Arboretum had most of its buds killed last winter, but some of the stronger terminal buds survived and have developed new growths of from one to two or three inches. Although beautiful in its native habitat, in cultivation it is a straggling plant difficult to grow and unworthy of planting in this climate. Some of the long-introduced foreign species wintered well. The Norway Spruce is bearing a good crop of cones and the trees show no winter injury. This condition may be due to the fact that the original seed came from a northern part of its range in Europe, rather than a southern district. The spruces which show greatest damage from the severity of the winter are those which have been collected in central and western China in the provinces of Hupeh and Szechuan. The latitude ranges from about 28° to 33°. Probably few interested people realize that the latitude of this Chinese collecting ground, which has been repeatedly explored to furnish plants for our northern gardens, largely corresponds to that of northern Florida and the southern half of Georgia. Florida ranges from a few feet above sea level over the most part to rarely 300 or 400 feet on the highest points. Southern Georgia averages higher than Florida, but much of the territory here considered is well under a thousand feet in altitude and rarely exceeds two thousand, although higher hills and mountains are more common above 33° of latitude. Trees or shrubs from the Florida and Georgia zones under notice would rarely be considered as worth introducing for permanency into our

northern states. The temperature of the same latitude in western China, however, is greatly lowered by the general altitude of the country, which is from one to two thousand feet on the lower levels to ten or twelve thousand feet or more in the higher mountains. However, the law which compensates latitude by altitude does not always work out evenly or satisfactorily. Precipitation, prevailing winds, geologic features, soil and other factors are influences to be considered. Estimation of latitude as related to altitude may be roughly stated, as in the allowance of one degree of latitude to 450 or 500 feet of altitude. As already stated, much depends upon other ecological considerations. The latitude of eastern Massachusetts may be stated as approximately ten degrees or 600 miles north of the latitude of central Szechuan. Although Kew Gardens, in England, are nearly 600 miles farther north than Boston, in a latitude corresponding to southern Labrador, the climate is wonderfully modified by the warm waters of the Gulf Stream. Late studies have shown that the dozen or fifteen supposedly new species and varieties of spruce recently brought from China may easily be reduced to less than half a dozen species, some of which had already been found by earlier collectors and been named. Some of these species or so-called species show very serious injury from the effects of the past winter. For all practical or ornamental purposes they would be generally worthless for eastern Massachusetts if we had occasional repetition of such a winter as that of 1934.

Picea asperata and its described forms has proved to be not dependable or desirable under such conditions. An examination of several trees at the end of summer showed that about half or more of the previous winter buds had failed to develop or to make any appreciable growth. Where such a large proportion of the buds are killed or stunted the surviving terminal or other buds often produce unusually long new shoots due to the concentration of growth into a few rather than many twigs. Under such circumstances the trees are likely to become permanently unsymmetrical. *Picea asperata* as a name for this species will probably disappear as a synonym, as it hardly differs from several other so-called species which have been brought from western China. It is clearly not adapted for successful plantings in regions with more severe winter climate than that prevailing at Boston, and even here we have seen that it is liable to serious damage in unusually severe years or situations, although there are trees in the vicinity where the plants are reported to have come through in good order. It may be that hardier races may yet be found in western China.

Picea balfouriana, from Szechuan, suffered so much damage from the severity of the past winter that it may be considered as unsafe to plant in this climate for permanent landscape effects. A tree 14 feet high showed all buds dead or badly checked. In midsummer the tree showed new leaves forming about the old dormant buds, but no new growths of twigs. A little further south or in mild or normal winters it may be attractive. It appears to be an older described species under a new name.

Picea purpurea was badly injured and is very unpromising for this region, although it may be a very desirable acquisition under less severe conditions.

Picea watsoniana, twelve feet high, had a very large proportion of its buds permanently blasted, a few escaping unhurt and now showing new extra long shoots. These extra vigorous survivors among the multitude of buds which have failed must eventually produce an unevenly developed and undesirable tree for northern gardens.

The true firs, belonging to the genus Abies, have long had a peculiar attraction for gardeners and landscape planters and there is naturally a particular

interest in all the species which are reported as hardy in our New England climate. We have few American species which thrive satisfactorily in the climate of Boston, probably the best being *Abies concolor* or White Fir of our Rocky Mountains. But to be hardy and satisfactory in New England the seed of this species must be procured from the drier, colder territory east of the Rocky Mountains, as in Colorado, for if grown from seed collected from west of the Rockies the results are far less satisfactory. This is true of most of the other splendid Pacific coast firs; they are too tender for satisfactory growth in central New England.

European firs, like the Nordmann Fir, *Abies nordmanniana,* and the Cilician Fir, *A. cilicica,* have long been grown here with much satisfaction. The past winter proved seriously injurious to both species. The injury took the form of causing the death of the hearts of a great many of the winter buds. The percentage of injury varied on different trees in different exposures. Usually on the most damaged trees some buds escaped. The result has been that by autumn, when all new length growths should have been completed for the season, the major part of the twigs and buds still appeared as they did the previous winter except that in some cases a few twisted green leaves developed at the sides of the dead buds, or new very short twigs were formed. The few leading buds which escaped injury produced abnormally long new shoots as a result of the failure of a majority of the buds to develop. The apparently dormant twigs were found developing scattered small buds in the axils of leaves. These may grow next spring and carry on growth a year late. The result is likely to produce very irregular and undesirable trees for ornamental purposes.

It was hoped that the introduction of firs from Japan and western China would add greatly to our available ornamental trees, but the experience of the past winter has shown that at least some risk from climatic changes is involved in using several of these species. They may appear to be doing well during a number of ordinary winters, and in favored situations, but a time may come when their behavior may prove very disappointing. The Japanese Nikko Fir, *Abies homolepis,* for example, on large trees on low ground, had a large proportion of buds winter killed, and the struggle to produce new buds and leaves was very apparent in late summer. If these latter survive and continue growth next year the result will probably be decidedly disappointing. On higher sheltered ground with good air drainage the trees show only a small amount of injury, although the conspicuous male flower buds, a third of an inch long, still remain hard and inert and are black and dead within. *Abies veitchii,* from Japan, considered one of the most beautiful of firs, was so damaged that gardeners may well be discouraged about planting much of it in localities with occasional very low temperatures. Recent studies of firs from western China seem to show that there are not so many species to be credited to that region as has been claimed. They did not endure the winter in a satisfactory way.

The larches (Larix) came through the winter in good order, except that in some cases the flower buds were destroyed. The behavior of the Japanese Umbrella Pine, *Sciadopitys verticillata,* in the Arboretum was interesting, inasmuch as out of six trees growing near together three retained their usual winter quota of leaves while three lost most of their foliage, but as the buds were still sound a new growth of leaves developed which partly recovered the seminakedness of the branches. These should have a full complement of foliage and attain normal appearance by the growth of another year.

The Bald Cypress, *Taxodium distichum,* of our southern states, in this

latitude usually loses the tips of branches and twigs in winter, but the defect is soon overcome by new growth. After the past winter this trouble was decidedly more apparent, but as the trunks and main limbs withstood the test they put forth belated new shoots and leaves. However, the trees are not ornamental.

Rather curiously, the Pond Cypress, *Taxodium ascendens,* which we have regarded as more tender than the other, as its general range is more southerly, came through the winter in fine condition and quickly produced its cover of light green foliage. As the two species are growing on the same northerly incline and within a few yards of each other the disparity in behavior was very interesting and unexpected.

The arbor vitaes (Thuja) behaved much as usual in other seasons, the giant western arbor vitae wintering wonderfully well. This was true also of the genus Chamaecyparis, commonly called cedar or cypress, names also applied to some other genera. Some injury was caused by browning of foliage and other minor injuries such as are frequently noticed after the average winter. Even the somewhat uncertain Port Orford Cedar or Lawson Cypress, *Chamaecyparis lawsoniana,* came through with apparently little injury on Hemlock Hill, although it makes poor growth on low ground. Some injury was noted on junipers (Juniperus), sometimes causing the premature shedding of minor twigs so that the trees or affected portions lost their clean greenness. But the branchlets usually appeared alive to near the tips, new growths appearing and giving promise that in another year the trees may present a more normal appearance. The dwarf spreading and the dwarf pyramidal junipers occasionally showed dead branches which probably succumbed after being weakened by other causes.

Incense Cedar, *Libocedrus decurrens,* 35 feet high, in the shelter of hemlocks, wintered much better than might have been expected, considering that it is a Pacific coast tree, west of the crest of the Rocky Mountains. The hardy race of Cedar of Lebanon, *Cedrus libanotica* or *C. libani,* introduced from Asia Minor, proved gratifyingly resistant to the unusual cold to which it was subjected. Some trees lost a considerable proportion of their foliage in the spring, giving them a very open and naked appearance, but as few leaf buds were injured beyond recovery new leaves soon appeared, so that by next year the trees will probably have returned to almost normal aspect. When first introduced here from Palestine, a couple of hundred miles further south, this species proved quite unsatisfactory.

For several successive years the Japanese Golden Larch, *Pseudolarix amabilis,* has flowered and fruited freely. This past winter the flower buds were destroyed by the extreme cold, so that this season the trees did not bear any of their interesting cones. The trees, however, were otherwise apparently uninjured, a fortunate circumstance, as the species is one of the most beautiful and interesting of hardy deciduous conifers.

The famous *Cryptomeria japonica,* of Japan and China, unfortunately has so far proved not well adapted to the climatic conditions of Boston, although it may be long persistent and attain some size. In the past winter trees 20 or 25 feet high had a large proportion of the weaker lateral twigs and leaves killed, but stronger buds at and near the ends of branches survived and carried on new growth.

The killing or partial killing of flower buds occurred on many species of conifers and other trees and shrubs in Boston and vicinity, although the plants may have appeared otherwise uninjured.

MAN MEDDLES WITH NATURE

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WHEN our forefathers settled the American continent, nothing seemed more certain than that the wild life and the natural resources were limitless and inexhaustible. Within recent years new conditions have developed so rapidly that we have witnessed the exhaustion of the inexhaustible and have observed the limitless approach the vanishing point. There are many evidences that these changes are in large part due to man's interference with the orderly processes of nature. Man has meddled with everything and has attempted to substitute artificial human standards of economics for the laws of nature. He views the results in terms of conquest of the wilderness and boasts of the advance of his civilization, but many of the things that he has done may be branded as flagrant destruction of and unintelligent meddling with the affairs of nature. Himself a product of nature, civilized man stands in open defiance of the laws whose operation brought him into existence. Like an anarchist enjoying the protection and advantages of laws, his actions reveal a disregard for the very codes which prevent his destruction.

In the days of the pioneers, it was possible to live off the land without exacting any serious toll from the native resources. The humble demands of logs for cabins, for barns and for fuel made no inroad upon the primeval forests. Deer, rabbits, squirrels, prairie chickens and turkeys graced the tables of the pioneer without at any time endangering the existence of the species requisitioned. Even the buckskin breeches and moccasins, beaver skin caps and buffalo robes of the pioneer made no serious threat to the original wearers of those skins. However, as civilization pushed farther westward, as settlements replaced the isolated cabins of the frontier, a new set of conditions was introduced. In one or two generations, the seemingly limitless supply of wild life faced a definite crisis. Dozens of species were brought to the brink of extermination, while a few were forced over the edge. The passenger pigeon was wholly exterminated, while bison, antelope and deer were rapidly approaching the same fate. The price at which our race has bought its advancing frontier includes not alone the stern injustice dealt to the savage natives. An even greater inhumanity has been meted to the wild life which only by a stretch of the imagination stood in the way of human advancement. Those who have seen justice in stealing lands from the red man, because the white man could make better use of them, will continue to find justification for the extermination of all forms of wild life as a sacrifice to advancing human frontiers.

The problem of determining man's responsibility for the annihilation of wild life is far from simple. Furthermore, reparations demand deeper consideration than mere passage of laws. Restitution is not completed by setting apart agriculturally unprofitable waste-lands as sanctuaries for the vanishing species. The real solution touches vitally upon the whole social, economic and industrial organization and operations of the human race.

In most courts, summary justice is dealt to the ignorant alien who kills song birds for food. Even if esthetic and recreational values to man be disregarded, every school child knows that as seed-eaters and insect-destroyers the song birds have direct importance to

man far outweighing their worth as food. The public feels a surge of resentment toward the poacher, the game hog and the illegal fisherman. For some strange reason, indignation lies dormant in the public breast when the public is confronted with the charge of dumping sewage into the streams and of allowing the infant industries to sneak their industrial wastes into the waterways. We are inclined to make a very sharp distinction between the individual breaker of the civil law whose guilt may be measured in terms of the number of dead animals found in his possession and the public, under-cover desecrators of nature, whose crimes are condoned as unavoidable accessories to progress. At so many points, temporary human interests come into open conflict with the laws of nature that the two are in perpetual conflict. Almost without exception, the human interests win, but at a disgraceful cost when the sum total of human welfare is measured.

Many uninformed people have thought that with the advance of our frontiers the disappearance of wild life has been due solely to the slaughter and destruction of the native animals and plants. On the contrary, convincing evidences point to the indirect responsibility of man as well as to his direct program of extermination. Alterations of the natural environment are highly effective in bringing about extermination of the plants and animals which held title to the land before civilized man pressed his claim. It often becomes difficult to differentiate and to evaluate the relative responsibility of these two factors. Thus, for example, either relentless slaughter or destruction of the prairies would have been sufficient to bring about the destruction of the bison, but together their effect was cumulative. From most of the western plains country the bison was driven by wanton destruction before the plow had ruined the natural range on which the herds depended for grazing. Man's interests and those of the bison were incompatible. Even in nature there are many species which seem to be incompatible. The appearance of one means the disappearance of the other from a given territory, not because of open conflict between them but because the two are unable to live together. Man frequently renders biological conditions unfit for the continued existence of native creatures without being aware that he is responsible for any change. Much more frequent than the slaughter of the original inhabitants is the destruction of their feeding and breeding grounds by changes wrought by human occupation. These changes are often of a subtle biological nature which would pass unnoticed except for a scientific approach to an understanding of the diverse problems of conservation.

Few wild animals can survive contact with man and remain unchanged. Their habits are much more firmly fixed and actions are frequently more rigorously controlled from within than most of us realize. Many acts which we as human beings perform and interpret as evidence of intelligence are performed by other animals in an unvarying, unmodifiable manner, suggesting that they are rereflexes or are possibly instinctive. We used to interpret the industry of the bee and the accuracy of the sting of the wasp in killing spiders and insects in terms of human intelligence, involving motives, but it requires only superficial study to reveal the fact that little intelligence and much of uncontrollable instinctive action here unite to give the impression of intelligent behavior. Many hundreds of animals starve annually in the presence of what seems to be adequate food supply because of their inability to substitute foods which to our human sense and dietetic understanding appear "just as good as" their natural foods. While we were going through that trying period of the world war perhaps we did not understand what life-giving value the train-

ing in acceptance of substitutes gave to us. Herds of deer have been known to starve when natural food on the native feeding range has been depleted, even though short journeys might have brought the herd into new territory with plentiful supply of natural forage.

One of the most serious problems challenging a program of wild life conservation in parks and sanctuaries of all sorts is the fact that conditions more favorable than those existing in nature lead to overpopulation. As a consequence, predatory animals tend to increase along with the multiplication of their prey. Here man steps in with a program of extermination of the predatory species. In eliminating the predators, he has approached the solution of one problem only to face a more serious one of overpopulation of the protected animals in the absence of the natural checks to overproduction. Man becomes the most important factor in the environment of any organism which directly or indirectly comes within his sphere of action. Even the forms of life which he aims to favor and to protect may become radically changed because of their contacts with man.

When man occupies a new area of the earth's surface, it is not a simple adjustment for the wild life to move on to an area unspoiled by human contacts. It is relatively easy to understand the disappearance of such large animals as deer and bison, when man kills them to satisfy his hunger and to provide shelter and even at times stoops to destruction for the gratification of the brute desire to kill. Unfortunately, the conspicuous changes in the fauna are but the beginnings of the modifications wrought by human occupation. Direct slaughter is no more surely an avenue toward extermination than is inability on the part of the native life to readjust to the new conditions imposed by man. As stated previously, destruction of suitable breeding and nesting sites is one of the most potent factors indirectly leading to the destruction of wild life. Yet, at the time, the individual is often unaware of the fact that he is guilty of desecrating nature. Biological relationships are too subtle and the public is too little trained in the sciences to have an understanding of the significant biological aspects of a program of conservation.

Some kinds of animals face man's severe influence upon the environment and survive. Even these rarely remain unchanged. The most frequent method of establishing a basis of relationship with man is by open challenge to man's right of occupation. This challenge may be supported by the fact that man's crops and stores provide conditions more favorable than any of the species ever experienced in nature. Regardless of whether the animal under consideration be a mouse in the pantry, a wolf in the sheepfold or an insect in the cultivated fields, it profits directly by human contact. Many animals are transformed by human contact from inconspicuous members of the wild life, fighting an uphill battle for mere existence, to prosperous competitors with man, challenging every human right and every step of human economic advance. These beings, which are not destroyed by the man-dominated environment, are not even degraded to the pauperized state which frequently marks domestication. Because life is made easier for them, they have more time for leisurely occupation of destroying human property. They become serious detriments to human welfare, and in popular parlance as well as in scientific usage are branded as pests. Man is apt to forget that his tampering with the affairs of nature has created the abnormal balance favoring these, his competitors. His disturbance of nature permits his foes to exist in wanton luxury, while for their kind any margin beyond mere existence is converted into increased numbers.

Frequently, animals find life so much

simpler under the conditions provided by man that they ultimately become more or less dependent upon human association. Chinch bugs in a cornfield have no need of thought for the morrow. Man, their benefactor, has set up conditions which enable them to devote their entire time to feeding instead of hunting for food plants. Natural limits to increase in number are wiped away and the chinch bug becomes a menace to the crops that made its life too simple. Rabbits and squirrels become more abundant in fields and orchards and in public parks than under the primitive conditions, for human protection grants almost limitless food supply and natural enemies are held in check. Bears in the Yellowstone National Park are becoming disgustingly civilized, preferring the garbage pits to the more laborious alternative of feeding upon honey, small animals and berries. Bluebirds, housewrens, swifts and martins are examples of birds which have become largely dependent upon nesting sites provided by man. It is yet too early to predict what influence this dependence may impose upon birds of the future. The tendency toward domestication is extremely significant. Many conservationists are not aware of its influence in a program of conservation. State agencies, clubs and individuals annually spend large sums of money rearing quail and pheasants under barnyard conditions. When these semi-domesticated birds are liberated they fall easy prey to the hunter or to the wild predator because they lack the wariness characteristic of the wild stock.

In the foregoing paragraphs we have reviewed some aspects of man's responsibility for the changes affecting our native living things. Let us turn now to the attitude which civilized man holds toward these changes. There is no field of public interest in which there are more prevalent and wide-spread mistaken notions than in the thinking on problems of conservation. The average citizen interested in a program of conservation calculates solely in terms of moneys, laws and public sentiment. He acknowledges some debt to nature but views the damages in much the same light that he rates property damage. Repairs can be made if there is money enough to foot the bills. The economic, civic and educational aspects of conservation have frequently been stressed to the exclusion of some fundamental underlying principles that have their roots in the biological sciences. Many people have erred in the thought that money in sufficient sums, laws that are adequate and a public sentiment in support of law enforcement are the only requisites for the perpetuation of the remnants of our native wild life to all future generations. Viewed from this angle, conservation is built upon shifting human emotions and interests, never reaching the firm foundation of scientific fact which alone can give it stability and even relative permanence.

Societies are formed for the protection and perpetuation of certain kinds of wild life, ignoring the fact that all living things are but transient features on the face of the earth and oblivious of the fact that change is one of the few inescapable laws of the entire universe. In terms of total human experience, changes in the forms of life under conditions of nature are unbelievably slow. Only by projecting the thoughts backward into a past inconceivably remote do we begin to realize how incomprehensible is the age during which nature has been engendering the plant and animal life with which we are familiar. Long before man entered upon the scene of earth history, there were conspicuous changes marking as distinct the forms of life which in successive periods inhabited our globe. As we now piece together the broken fragments of the picture of the past, we see that thousands of actors in the pageant of life took their cues, trod

the boards in the drama of evolution and made unrecorded exits as the scene of one period drew to a close and the curtain of another rose to reveal a new cast of characters in new rôles with new habits fitting each to its surroundings.

Nature, so often viewed as a kindly mother of life, has been ruthless and wanton in her treatment of the individual. Evolutionary progress has been made possible only through the sacrifice of individuals in the blind struggle for endless change in the races of living beings. In rapid succession, entire species have been wiped out to make way for others, better suited to a changed environment and therefore better fitted to live. So great is the period of time and so profound are the changes that mark the transition from one era to another that the same species rarely bridged the gap between eras. Though these facts are generally known, in our human limitations we talk of perpetuating a given species when the entire history of life reveals the untenability of considering any species as permanent. For sake of sentiment, we plan for the perpetuation of redwoods, of bison, of antelope, though we know that in the plan of nature each species is but a transient. Even man who does the planning has no assurance that his race is more than another temporary participant in the pageant of the ages. Our concepts of time are relative. Individually, man thinks in terms of one lifetime. As a race, direct experience of time is limited to the few thousand years of human history. The geologists and astronomers have forced us to think in new concepts where a thousand years are as but a day and millions of years become the common unit for estimating periods of earth history.

In seeking the causes for changes in the forms of life upon the earth, the average person is apt to think that physical changes of the soil are entirely independent of living things. It is a well-known physiological fact that animals and plants themselves produce changes in their environment which eventually render the surroundings more suitable to other forms of life than to the organisms living there. A soft-wood forest in time becomes converted into a hard-wood, not by transmutation of the original trees but by climatic transitions and by changes in the soil, rendering it more readily adapted to the needs of hardwoods. Acorns and maple seeds, fortuitously introduced in such a woodland, find congenial conditions and grow, ultimately replacing the original trees when these reach old age and die. Thereby, one type of forest is gradually transformed into another largely through the agency of changes produced in the soil by living things.

Accompanying the changes in vegetation, animal life undergoes parallel modifications, for it is not accidental that certain kinds of trees and plants are found under a given set of physical conditions and that particular kinds of animals are almost invariably associated with certain types of vegetation. Hunters do not go to the cornfields to find squirrels, nor to the oak-hickory forest to shoot rabbits. The brook trout and the musky are not found in the same waters. In addition to its physical surroundings, every form of life has certain biological limits to its distribution, certain kinds of plants or animals with which it habitually associates. So intimately is the individual organism adjusted to its living environment that many biologists have come to consider that the individual plant or animal is not the natural unit of life. Since all living things in a given space comprise an integrated unit of life, representing a most sensitive balance between favorable and unfavorable influences, many students choose to adopt a distinctly sociological interpretation of life, viewing the individual as a subordinate part of a larger social system. Whenever

balance within the system is disturbed, new adjustments have always been imminent. Climatic changes, physical disturbances in the environment, elimination of one species and introduction of other species are among the most common disturbing factors necessitating readjustment. Sometimes new forms of life have been molded under the influence of altered conditions, and progressive evolution has followed. Sometimes the native species have been unable to make the necessary readjustments so that death of the individuals ultimately spelled the death of the race. Many animals and plants in the past have been unable to keep pace with the demands of a changing environment and in consequence entire groups, such as the dinosaurs and the native horses and camels, became exterminated and are now known only through their fossil remains.

We have reason to believe that the changes which necessitated readjustment and led to the ruthless extermination of those forms which failed to adapt themselves were, in most instances, extremely slow, requiring thousands or even millions of years. As a disturbing factor, creating changes inimical to the continuation of life as it exists in nature, man has been able to produce in a single generation changes that can be paralleled only by processes operating over long periods of geological time. Without qualification, civilized man is the most destructive influence that has ever been introduced to upset the delicate balance of reaction and interaction between organisms and their environment. Part of his disturbance may be credited as unavoidable, but in large measure it takes the form of either wilful or thoughtless destruction, in no manner advancing either the individual or social interests of man.

By wasteful lumbering methods, man devastates a forest, thereby putting an end to definite, orderly successional processes of nature which have been operating through thousands of years. Man destroys in a day what nature has required ages to accomplish. Rings in the stump of a fallen oak may give evidence that the three or four hundred years of its life outspan the total period of our history as a nation. But even this age, which the annual rings reveal, marks only the final period in a much longer series of preparatory stages leading up by long and tedious conditioning of the physical and biological environment in anticipation of that oak. One does not need to be intimately familiar with the aspen thickets of the cut-over country to appreciate the fact that destruction of a mature forest sets nature back to an early stage in biological succession.

When a forest is cut off, the animal life dependent upon and developed along with that forest disappears. Some of the large and active forms may be able to migrate to similar adjacent regions, but even there they upset the population balance and confront new problems in the struggle for existence. In speaking of the changes which accompany deforestation, it is not alone the large conspicuous animals that are affected. Insects, spiders, snails, even the earthworms and the countless myriads of smaller animals accustomed to forest conditions disappear when the trees are gone. Most of the species are replaced by a wholly different population. Even the lowly vegetation of the forest-floor becomes modified after the timber is gone. On recently cleared woodland it is a pathetic sight to observe the pining mandrakes, ferns and lady-slippers deprived of their inseparable companions in nature, the trees.

The tale is not completed when an inventory of the changes in plant and animal life has been taken. The loose forest soil is exposed to unaccustomed erosion and evaporation. Sun-baked humus no longer holds a reserve supply of water. Floods result. Publicity is given

to the economic losses and human suffering entailed by floods, but rarely a mention is made of the toll of native life. Rarely are we logical enough to place the responsibility on the shoulders of fellow men who destroy the natural flood preventives. We prefer to blame the river which has gone on a rampage rather than the citizen who in his greed has stolen the natural flood plains from the river and has robbed the river of its forests. Human responsibility for damages does not stop with the change in plant and animal life accompanying deforestation and loss of life and property in subsequent floods. The selfsame floods carry the surface soils into the streams, not alone reducing the value of the land by erosion but also destroying the lakes which act as catch-basins for the eroded soil and in time are transformed into mud holes and swamps. Here again a series of successional stages, relatively slow in nature, becomes unbelievably accelerated by human interference with nature. A pond or lake surrounded by cultivated fields rapidly passes through the successional stages of transformation to marsh and final obliteration, leaving nothing but a meandering stream. Even this final stage of nature is wiped from the face of the earth by conducting the water in underground tiles.

The agriculturalist and the economist may maintain that drainage of swamps and of back-water lakes is good economic practise. They may even be able to compute the enhanced value of the reclaimed land in terms of increased tillable soil. In this country, with overproduction staring us in the face as one of the most serious handicaps to economic recovery, we are beginning to realize that many types of land are better suited to reforestation than to cultivation. The economic returns of scientifically conducted aquiculture may be much greater than returns from agriculture on the same area. From afar we can diagnose the ills of China, recognizing that floods and famine are natural accompaniments of deforestation and removal of all ground cover. At close range our judgment seems to lose perspective, and relying on superior wisdom we proceed to practise deforestation and permit private enterprises to drain bottomland lakes. In this country, with few exceptions, reclamation projects which have endeavored to rob natural waterways have been financial failures to all except the promoters.

Thus, whether we view the land, the natural vegetation that grows on the land, the animal life which this vegetation shelters and in a sense selects and develops or the waters and their life, we find that human intervention produces changes in a few years which require ages for their consummation by nature unaided by man.

Before civilized man came onto the scene, all nature hung in a delicate state of equilibrium, a condition which students have chosen to call "the balance of nature." Changes, regardless of how large or how slight, were followed by readjustment. The old Malthusian doctrine operated with a vengeance. The inherent tendency for every species to produce more offspring than could possibly be sustained yielded the material upon which survival values for the fittest operated to maintain the balance of nature, not on absolutely even keel, but running in periodic waves. Elk and deer were held in check and were improved by limitation of suitable range and by natural enemies. A season of unusually favorable circumstances, resulting in excessive increase in the number of young and more than sufficient food supply, brought a temporary increase in the numbers of deer and other grazing and browsing animals. Such increases did not continue indefinitely, year after year. After a time came a period when predatory animals, which had prospered because of abundance of

their natural food, became relatively more numerous than their prey. Natural checks to excessive numbers were thus established. Over a period of years the population of each species represents a delicate balance or compromise between favorable and adverse conditions of the environment, and for each species both living and lifeless things go to make up that environment. The composite of these delicately balanced conditions for all forms in a given region results in establishing a sort of general balance or equilibrium for the whole area. Man with his ability to dominate his surroundings destroys this natural balance and in so doing opens a Pandora's box of troubles for himself. To satisfy his wants more readily, he long ago ceased from hunting for the scattered fruits and grains which his forebears sought and depended upon for nourishment. For his own convenience he now plants several hundreds of acres at a stretch in a single crop. In catering to his own convenience, he has at the same time made life easier and more certain for the hundreds of different organisms which had been dependent upon the scattered plants under conditions of nature. Without man willing it, these natural associates of his crop plants thrive to an extent never before possible for them and become competitors with man for the fruits of his labor.

To-day we have hundreds of species of insect pests, some of which challenge every advance made by the human race. Even some species of birds may become pests and many predaceous mammals interfere with man's program of meddling with nature.

When game animals are herded and protected on preserves and reservations, man has caused a serious disturbance of the laws of nature. Under crowded conditions, communicable diseases assume more serious proportions than they ever attain in nature. We have recently witnessed a sorry plight in the Jackson Hole country. There natural food supply is wholly inadequate to care for the elk which have multiplied excessively under their semi-domestic conditions, deprived of their natural checks to overproduction. Even more strikingly our government has been confronted by a serious problem in the Kaibab Forest and on other preserves where game has multiplied abnormally. With the unnatural population, predatory animals, such as coyotes, wolves and mountain lions, have been favored until governmental agencies have considered themselves forced to inaugurate a program of extermination. All this because we have lacked an appreciation of the natural laws and thereby have rendered the conditions of existence too favorable for the animals which we have sought to protect and at the same time too favorable for the natural enemies of the objects of our benefaction. This is a marked instance of a case where will, intent, legal enactment and financial support were all focused on a program of conservation. But the program has in a measure failed because due consideration has not been given to the natural biological aspects of the problem.

There are many other examples of failure of conservation measures traceable to insufficient consideration of facts, especially in many game and fish laws. With the best of intentions, state legislatures have in the past enacted laws providing closed seasons for the protection of game animals, birds and fishes. In many instances it has been discovered that these closed seasons have failed to coincide with the period of the year when the young are being produced or when eggs are being cared for. Few organisms pay particular attention to the calendar. The breeding season of the black bass varies from year to year, depending upon temperature of the water and a complex of variable factors which can not be expressed in terms of exact calendar dates. In some localities,

many breeding fish have been caught from their nests because a fixed date intended for their protection failed to coincide with the advance of the season.

One of the gestures in the name of conservation which is frequently devoid of any biological background in its application is the attempt at increasing the population of wild life by planting fish and by breeding game birds and animals. As administered by most agencies interested in these activities such work becomes largely a political matter in which no direct ends above political favor are sought. There is no merit in liberating quail or pheasants on farms where no suitable cover or feeding grounds are provided. There is no biological justification in dumping a carload of fish in a stream which is wholly unfitted for maintaining fish life. When a stream becomes barren of fish it is relatively easy to satisfy the public by restocking it. No self-respecting political agent of the public would dare to inform his public that their streams are so rotten with sewage that no fish with a standard of living above that of a carp could take lodging in them. Such information belongs to the pedantic biologists and has no place in the thinking or program of the political conservationist.

In a few generations we have seen the rivers which sheltered the finest game fish desecrated and turned into open sewers unfit for supporting life or for giving recreational enjoyment. Many have condoned this act as one of inevitable necessity, but to the biologist and to the sanitary engineer no legitimate excuse may be offered. Stream pollution is a crime against nature and against society for which man has paid dearly and will continue to pay even more dearly in the future if the evil is not abated. When cities depend upon water supply from rivers, stream pollution becomes a very serious problem. Where cities are far separated, the wastes of one have the opportunity of becoming naturally purified before the stream reaches the next village. With increased loads of pollution, due to increased size of the civic units, and with the increased density of population, natural chemical and biological processes are incapable of breaking down the wastes from cities up stream before the river is called upon to provide the water supply for cities farther down. The obvious result is that the less fortunate city is compelled either to use the sewage of the other cities or to install expensive systems of treatment to render the sewage safe for domestic and industrial purposes. Responsibility for damage to the water supply should be attached to its source. In this age, no city or organization has the right to impose on others the cost and responsibility for purification of its wastes. From the point of view of justice and of public health, sewage treatment is one of the prime obligations which each community must meet ultimately. On the biological side, the problems of pollution run into incomprehensible figures of economic wastes and deplorable faunal losses. In a few weeks by domestic and industrial pollution man exterminates all the valued animal life from natural waters to an extent equaled only by the ages required for similar losses in nature.

In a number of places throughout the foregoing paragraphs reference has been made to the balance or tendency toward equilibrium in nature and the disturbing elements which, destroying equilibrium, superimpose a definite cyclic phenomenon over the general tendency to maintain a level. Similar cyclic phenomena may be noted in regard to man's disturbances of the natural order and these offer a hopeful note sounding above the discord of man's inhumanity to his fellow creatures. The severity of man's influence upon the living things of his environment seems to undergo a definite progressive change as civilization ad-

vances. The first broad contacts of man and nature are severe and the severity increases up to or just short of the vanishing point for many of the native species. This may mark the turning point and, in the following readjustment, conditions again become favorable for the remnants of wild life. Let us trace this cycle in the older, long settled regions of our country. In the eastern states the first contacts of the settler imposed few changes upon the life of the region. With introduction of intensive systems of agriculture and increased density of population, conditions became progressively more adverse for the native life until local extermination resulted. The same spirit of wantonness which has marred man's attitude toward the native wild life has characterized his disregard for the soil. In many of the older parts of the country, the soil has become exhausted and the farms have been abandoned. On these abandoned lands a new cycle of life is becoming established. Under conditions where adequate protection by law is offered, game animals and other forms of wild life increase to an abundance rivaling the primeval condition. Some scientists have seriously doubted the permanence of the human race. If it is true that the evidences of organic decline and potentiality of self-destruction through the creation of machines and discovery of destructive agencies may lead to man's downfall as a race, it is possible that nature in the future may be able to rebuild herself and that man's interference with her plans may prove to be another one of the transient features in the plan of the universe.

Throughout this discussion, I have intentionally set man and the conditions which he creates over against nature. Some might object to this as illogical and maintain that man as a product of nature should not be set in antithesis to the remainder of the natural environment of our native wild life. Through his use of machinery and his ability to modify the environment to meet his own needs, man introduces a whole new code of laws apart from and all too often in direct conflict with natural law. It is on this ground that man as an influence upon nature, of which he is an integral part, is set over against nature as it operates when freed from human interference. By his contacts, man accelerates changes which take infinitely longer periods of time without his intervention. In the natural environment civilized man is a catalyst producing most profound reactions. Usually these reactions have been to the detriment of most forms of life with which he comes into contact. These destructive agencies are capable of reversal. It is entirely possible for human society through adequate recognition of natural laws to avert extermination of the remnants of our vanishing wild life and to bring back clean streams with their characteristic life.

As much as our federal and state governments have done toward setting aside refuges and sanctuaries in our national parks and forests and in the states parks and preserves, only a beginning has been made looking toward restitution of conditions. No program of conservation can ever attain the full measure of its ends until complete recognition is given to the body of underlying scientific facts which elevate conservation from the ranks of the political system.

Meddling, even that growing out of the best of intentions, must be replaced by intelligent understanding and actions before conservation may become a reality.

WHAT PREVENTS SOCIAL PROGRESS?

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I. Science and Invention

As they contemplate the muddle of human affairs in the world to-day, a chief question in the minds of all thinking people is—"Why, with such wonderful inventions as science has made possible, have we not been able to utilize science in bettering our human relations? Why can not science produce social as well as material progress?" Obviously, we have made considerable advance in the art of living together, in spite of the feudal domination of our large cities by gunmen and racketeers. Our grandfathers abolished human slavery, the present generation has largely stopped child labor, hours of industrial workers have been shortened, a rapid increase has occurred in high-school education, play and recreation have increased, and there has been rapid improvement in medical care and health facilities. But with a superabundance of goods thousands of able-bodied, self-respecting people are cold and hungry, and life is chaotic. If science can invent machines and processes which make it possible to produce all the goods necessary in a much shorter work-day, as the engineers assure us is now possible, why can not science also show us how to adjust our human relations so that we can all have a chance to enjoy the advantages which it has made available?

I have no panaceas, but I believe that by analysis we may secure a better understanding of what is involved in social progress and how it may be achieved. Nor shall I attempt to define the term "social progress," which I shall use in a common-sense manner. If we think of the advantages we have in the use of electricity, radio, automobiles and the multitudes of modern inventions as social progress, it is obvious that science has done much to lighten labor and make life easier and more enjoyable. But when we study the present economic cataclysm of the world, we wonder whether all these things have really contributed essentially to progress in our human relations.

Even before the technologists forced it upon our attention, it was apparent to most of us that science and invention have created a new world with such rapidity that mankind has not been able to adjust its methods of living so as to advance and preserve the general welfare. Science and invention—including discovery—are, therefore, chiefly responsible for our present situation. It is unnecessary to recount how recent inventions have revolutionized our environment in the present century, for that is known by every child. These new inventions tend to dominate our mode of life and to set the standard of our values. Instead of a home or children, many prefer a better automobile. On the other hand, in many ways we have not adjusted our old habits to modern inventions. Rural people go twenty miles to see moving pictures by means of the automobile, without a thought; but these same people cling to the open country church and the one-room schoolhouse. Inventions have made our cities possible and city life has brought many changes in the mode of living, but most of the customs and attitudes of the average city person have been largely determined by the rural environment from which he came. Inventions in many ways determine and dominate human relations, but they also create new values which change our social attitudes. Thus railroads created the cities, but automo-

biles are now taking people into the country and are giving them a new appreciation of nature. Cities and modern methods of communication made advertising profitable, but city people who wish to see the beauty of the country resent the interference of huge billboards and are commencing to demand legislation which will do away with them. On the other hand, we have not learned how to prevent the slaughter of the innocents by automobile accidents, which cause more deaths and injuries every year than our troops incurred in the world war.

Why, then, if science has been able to give us such marvelous material inventions and discoveries, so that we live in a material environment beyond the dreams of Jules Verne and Edward Bellamy, can not science give us social inventions which will enable us to solve the relations of capital and labor, the difficulties of the farmer in his efforts to maintain a worthy rural civilization, the money and banking problems, and to enjoy international peace instead of spending most of our national budgets in the insanity of war?

If you will but think for a moment how the methods of science have created the material inventions which we now enjoy, it will be apparent why science has not made equal progress in social inventions. In the first place, the inventions and discoveries of scientists are not mere creations of the brilliant imagination of some individual genius. Every major invention or discovery is but the recombination of facts which hundreds and thousands of workers in the physical and biological sciences have laboriously brought together into a systematic body of knowledge during the past centuries. In the report on "Recent Social Trends," Professor W. F. Ogburn says: "An invention cannot be made unless the elements which form its base are in existence. The Greeks with all their intellectual powers could not invent the airplane, because they did not have the gas engine and their supporting devices. The larger the number of elements in a culture, the more numerous the inventions. Their growth seems to be somewhat like compound interest; the bigger the principal, the larger the interest." Recently the possibilities of scientific discovery have been so apparent that large corporations and private institutions support huge laboratories with large staffs of trained scientists who are wholly engaged in research.

On the other hand, the social sciences, economics, political science, sociology, anthropology and psychology, were born only at the close of the past century, although many of their ideas go back to thinkers of ancient Greece. There have been no such facilities for research in the social sciences as in the physical and biological sciences, for we have not become convinced that science can aid us in solving our social problems. A generation ago the older type of manufacturer was running his business largely by rule of thumb and made little use of science. To-day he can not compete without the aid of scientific experts.

More important, however, than the lack of scientific research and a consequent body of scientific knowledge with regard to human relations comparable to that which has been created in the physical and biological sciences, is the fact that inventions and discoveries of the physical sciences may be manufactured by individuals and corporations for *profit*. Social inventions and discoveries, on the other hand, yield no immediate profit to any particular individual, but are created for the common good. There is no pecuniary reward for the social scientist, and no immediate profit to any one in the use of his discoveries. On the contrary, social inventions which may ensure the general welfare usually are in opposition to the profits which some particular class or group of men have been making. They naturally oppose any change in the existing organiza-

tion of society and persuade the masses of the people that the discoveries of the social scientist are mere vagaries and academic theories, or they seek to arouse antipathy by branding them "pink." Many of you can remember, as I can, when intelligent people actively debated whether the microbe theory was true. It was an academic theory. But to-day our whole system of sanitation and medical science is largely due to the discoveries of bacteriologists.

Not only is there no immediate profit to the individual in the discoveries of social science, and frequently an opposition to vested interests, but there is an emotional attachment to our habitual ways of human association which makes it difficult for us to change them and which makes us exceedingly conservative with regard to discoveries in social science. We can see the advantages of an automobile; we can try it out, and if we like it, we buy one and it is nobody's business, so long as we do not have an accident. But we have an attachment for the church, the school, the family, our local government, our way of doing business, which is not so easily overcome as changing from a buggy to an automobile. Furthermore, in these forms of human relations and social organization many other individuals are involved and we can not as individuals adopt a new social invention.

II. The Opposition to Social Inventions

It is evident, therefore, that the adoption of social inventions or the discoveries of social science must await a process of education until the people concerned are convinced of their value.

This principle has been so clearly stated by my colleagues, Professors G. F. Warren and Frank A. Pearson, in the preface to their recent book on "Prices," that it may well be quoted as an illustration. "One reason," they say, "why progress in production is more rapid than monetary progress [and please remember that money is a social invention] is that production is subject to individual experimentation. The individual who has a new idea tries it out, even though he is ridiculed by the public. If the idea works, the successful demonstration hastens general adoption. Monetary progress can come only by legislation. It can proceed only as fast as popular education and vested interests that would be temporarily inconvenienced allow it to go."

By this time I hear some reader asking, Just what does he mean by social invention? We know such inventions as the telephone and the radio, the gas engine and the airplane, but what are social inventions? Social inventions are those which are used by society or groups of people rather than by individual persons. They are not material things, but are new ways of human association whereby definite services and functions can be performed which were not possible under the previous forms of social organization. The corporation is an excellent example and has so revolutionized our economic life that to-day we live in the age of the corporation, just as the people of medieval Europe lived in the Feudal Age. The corporation is a legal institution, but it is primarily a social invention. We are just commencing to get over the hate of corporations which was the common attitude in the days of our grandfathers, for this new creature of the law was able to do many things which individuals could not and it was felt that it put the individual at a disadvantage. That there was warrant for this feeling is confirmed by the history of the growth of corporations. A recent book by Professors Berle and Means of Columbia University on "The Modern Corporation and Private Property" informs us that the 200 largest corporations in this country have assets of $81,000,000,000, or 22 per cent. of the total wealth of the United

States. Obviously, we have some very real problems in the control of corporations so that they may best serve the general welfare rather than merely make profits for their stockholders, but no one would advocate doing away with them, for they have shown their ability to perform many services which we could not have had without their invention.

In quite a different field of human activity the Sunday School when it was first established in the beginning of the nineteenth century was certainly a social invention, as was its contemporary the public day school. Both of these new institutions were violently opposed by the conservative people of those days as being entirely unnecessary and as being inimical to the general welfare. The public school was declared to be a most dangerous socialistic institution, and the Sunday School ran counter to the current theology of those days and has ever been an institution of the laity rather than of the clergy.

Cooperative societies of all sorts are another type of social invention, differing from the corporation in that the profits or savings are divided among those participating in the business rather than by the stockholders. Consumers' cooperation has never achieved the success in this country that it has in Great Britain and Europe, but in Great Britain it has the same position in the retail trade as our largest systems of chain stores. Commencing in 1844 with the Rochdale Equitable Pioneers' Society, this movement has grown until in 1929 the cooperative retail stores in Great Britain did a business of over one billion dollars, and produced their own goods through manufacturing or agriculture to the value of over $300,000,000. In the United States cooperative associations for marketing farm products have made a rapid growth in the present century and in some years their business has amounted to as much as $2,500,000,000 or not far from one quarter of the annual sales of farm produce. Both cooperative consumers and cooperative marketing associations were violently opposed by private dealers and corporate business concerns, and only recently in this country have they won the recognition and support of the government.

Other social inventions which may be mentioned as illustrations are community chests for the support of social welfare organizations, juvenile or children's courts, the direct primary, 4–H Clubs, clinics of all sorts, mothers' pensions, workmen's compensation, the visiting teacher, social settlements, group insurance and the Federal Reserve System. All these, and a host of others, embody essentially new combinations of old forms of human association, and are just as truly inventions as any of those produced in factories.

All these social inventions have been welcomed by progressive and public-spirited individuals, but in most cases a few of those who saw the advantages of the new invention worked for years against the strongest opposition until they were able to convince the majority that it should be given a trial. What a contrast to the marketing of an invention like the radio, for which there was such an immediate demand from individuals that manufacturers were unable to keep up with their orders. Physical inventions may be adopted by individuals, but social inventions must be accepted collectively.

However, after they have once been adopted and become established social inventions become social institutions and a certain sanctity is attributed to them which arises both from use and from the fear that any change would endanger the established rights and relationships. Money is a good example of how a social invention has become sacrosanct. In an address before the American Farm Bureau Federation Dr. G. F. Warren expressed this when he said: "The 'money illusion' is as thoroughly domi-

nant in this generation as was the illusion of the flat earth about which the sun revolved in the time of Galileo. It is almost as dangerous for an economist to challenge the money illusion as it was for Galileo to threaten the foundations of civilization by saying that the earth revolved.''

It is this emotional attachment to old ways and fear of experimenting with new ones, and the fact that social inventions must be adopted by the many rather than by individuals, which makes it impossible for social inventions, however rational or worthy, to be adopted suddenly. Many a seemingly good law has been unenforced or has been repealed because the mass of the citizens were not as ready for it as the progressive and intelligent leaders who sponsored it. The acceptance of social inventions involves new social attitudes and really new ideas, both of which are painful. Social inventions may be for the general welfare, but the average individual is usually more concerned with his own welfare and that of his family, and only occasionally or under dire pressure, such as occurs in times of war and such crises as the present economic situation, is he forced to see that his own welfare is bound up with that of others.

It is evident, therefore, that social inventions will find a welcome only when the old ways have become outworn and fail to meet the existing situation, and when the individual finds that his personal welfare can be obtained only through new methods which will reestablish the general welfare.

III. Individualism vs. Social Welfare

In commercial language, the ''sales resistance'' to social inventions is very great and is more difficult to overcome with a group than with an individual. Only occasionally do crises arise in which one finds that his own welfare can be obtained only through changes which ensure the general welfare.

Thus arises the paradox of what seems to be a conflict between the welfare of the individual and the welfare of society, which in one form or another is as old as the human race. Social progress depends upon some resolution of this conflict of the interests of the individual and the welfare of society.

The last century and a half has been an era which glorified individualism. The American and French Revolutions were not merely political. Their slogans of ''Liberty and Equality'' were aimed not only at tyrannical governments but expressed the desire of the common man to be able to carve out his own destiny, freed from the social and economic restrictions of aristocracy and the privileged classes. In America these ideas literally had a fertile soil in which to flourish, for free land made it possible for the people to act upon them in securing a new economic independence. Both the political ideals and the conditions of life of the pioneer bred independence and an emphasis upon rights rather than upon duties. The latter developed only as joint action became increasingly necessary with a denser population. The whole philosophy of the times was one of individualism and *laissez-faire,* which very naturally took root in the dispersed settlements with an abundance of free land beyond them. Not only free land, but abundant natural resources for exploitation and the numerous scientific inventions which made possible the manufacture of new goods encouraged and rewarded individual initiative, and there seemed to be no bounds to individual achievement.

To-day the situation is entirely changed and although we still cherish and admire a worthy individualism, we are compelled to admit that it does not have the opportunity that it had a century ago. To-day the average individual is no longer free to carve out his own destiny as could the pioneers in agriculture and industry.

Due to the rapid growth of cities and

better means of communication and transportation, the complexities of modern civilization have brought about an interdependence of our whole economic life, which forces us to consider how the needs and interests of the individual may be satisfied by social inventions which will better ensure the common welfare upon which he is dependent. Free land will no longer give the farmer a living, for he is dependent upon markets and better means of marketing in order to secure the goods which his present higher standard of living demands. The workman can no longer choose his job, but is dependent upon the policies of large corporations and he must belong to an organization by means of which he can bargain with them if he is to maintain his right to a reasonable wage. Even technical or professional skill is no guarantee of a living; witness the thousands of highly skilled professional musicians who are unemployed because of the mechanical production of music by the moving picture.

To-day individualism may still be an ideal, but it does not enable the individual to meet his needs or satisfy his desires as it did a century ago. The farmer is compelled to join cooperative marketing associations if he is to market his produce to advantage. He no longer raises merely what he needs for his own consumption, but he grows what the market demands and the kinds of crops which his neighbors grow so that there may be a sufficient volume of product and that it may be so standardized, packed and processed as to make it marketable to the best advantage. The industrial workman must belong to a trade union if he is to have any protection with regard to wages or working conditions. The local merchant must associate himself with others in buying pools so as to compete with the chain store, and even the manufacturer is forced to join trade associations and agreements in order to protect his interests.

Not only this, but with the increasing interdependence of commerce and industry we have become painfully aware that anything which affects one class, the city or the open farming country, affects the other, and that the welfare of the individual is increasingly dependent upon the common welfare.

Does this mean that we must abandon individualism and that there is no merit in the individual initiative which has been so extolled as the basis of American progress? By no means. Without individualism life would lose interest, society would be reduced to a dead level, and there would be little chance for invention or progress, either material or social. But there is a difference between the individualism which is self-centered and which seeks only its own immediate interests and the individualism which finds its achievement and satisfaction in serving the common welfare. The welfare of the individual and of society are not necessarily conflicting, and social progress has never been and never will be obtained except through the devotion of individuals who see that a satisfactory individualism is possible only under a social order which ensures true freedom and justice to all. In the past we have emphasized the rights of the individual. In the future if those rights are to be secured, we shall have to give more emphasis to the duties of the individual. This has been well expressed by Miss Mary Follett in her book "The New State," where she says: "The history of democracy has been the history of the steady growth toward individualism. The hope of democracy rests on the individual. It is all one whether we say that democracy is the development of the social consciousness, or that democracy is the development of individualism; until we have become in some degree socially conscious we shall not realize the value of the individual" (p. 162).

"Yes," you say, "we agree with your platitudes, but granting all that, and although social progress is probably de-

sirable, just how will it get us out of our present difficulties?" The answer is that any adequate or even partial solution of our present economic and social problems will be a step in social progress. It will depend first upon our being willing to abandon some of our old concepts of self-centered individualism and our ability to see that only through sacrificing what we have conceived to be the inalienable rights of the few will we be able to secure the rights and opportunities of the many. The present economic and social disorganization forces us to take such an attitude, whether we will or not, just as we are forced to place the common welfare first in a time of war. But this is not enough. How to win a war or how to conquer economic disorganization is a technical problem and can not be solved by any amount of human devotion and good will. We face new issues concerning which the wisest and most devoted of our leaders can do no more than utilize the best knowledge available. But even if their solutions be correct, the answer will involve new social inventions, new ways of economic and social organization, the success of which will largely depend upon whether the rank and file of us common citizens understand them and are willing to wholeheartedly and fairly try out the experiment; for the determination of the value of any social invention is always an experiment. So we come to the conclusion that under a democratic form of government, unless we are to abandon our ideals of democracy, if new social inventions which are necessary for the general welfare are to be utilized, their success will largely depend upon an adequate understanding of what is involved and why the interests of each individual citizen, and hence the good of all, will be obtained through them. We are forced then to the conclusion that social inventions will succeed only as the people concerned in them are educated to understand the various factors involved and the nature of the advantages which they will secure. True social progress can go no faster than the general education of the people concerned. One reason that social progress can no longer be stopped is the rapid increase in high-school education in this country during the present century. One of the cardinal tenets of our American belief in democracy has been that it must rest upon the education of the people. The theory is sound, but the mere education of the children and youth in the use of intellectual tools is not sufficient for the preservation of democracy to-day. We have come to a time when the schooling which we received in our youth, based on the experience of previous generations, is no longer adequate to solve the problems of a new and ever-changing environment. We need a new type of individualism which sees its opportunity in the common welfare, but to succeed in this aim, men must be ever re-educating themselves to understand new problems as they arise.

IV. Education versus Democracy

So we come to the problem of "Education versus Democracy." Not that we disbelieve in education for democracy, or that there is a real antithesis between them, but that democracy without education is impotent and may defeat its own desires.

In the nineteenth century we seemed to have a naïve faith in a sort of Jacksonian democracy; that universal suffrage would ensure right decisions and prove the merits of political equality. Although probably few of us would vote to abandon universal suffrage, yet we have become disillusioned as to its efficacy for good government. Science has confirmed human experience that men are not equal by nature or training, and that, lacking knowledge of the issues, the number of votes cast does not ensure a wise decision. Nor are we so sure that political equality gives us democracy, for we find that democracy

involves equality of opportunity, and that there is no equality of opportunity without economic democracy; business may manipulate politics.

It is not necessary that we attempt any exact definition of democracy, although it may be useful to gain some notion of what we mean by the term, for it undoubtedly forms one of our criteria of social progress. Harold Laski says that the essence of democracy is in "a demand that the system of power be erected upon the similarities and not the differences of men." Fifteen years ago Dr. Liberty Hyde Bailey wrote a little book entitled "What Is Democracy?" in which he gives us the spirit of democracy so clearly that I quote a few paragraphs (pp. 36–42):

> Democracy [he says] is primarily a sentiment—a sentiment of personality. It is the expression of the feeling that every person, whatever his birth or occupation, shall develop the ability and have the opportunity to take part. Its motive is individualism on the one hand and voluntary public service on the other—the welfare and development of the individual and of all individuals. . . .
>
> If the person is to be placed in the most advantageous conditions and environment, so will he desire a similar privilege for his neighbor and voluntarily assume the responsibility of which I speak. The yielding of advantage to another, the giving up of granted "rights," that another may have a larger life, are in the very essence of the democratic state.
>
> Responsibility, not freedom, is the key in democracy—responsibility for one's self, for the good of the neighbor, for the welfare of the Demos. Until every citizen feels this responsibility as an inescapable personal obligation, there is no complete democracy. . . .
>
> I find the root of democracy in spiritual religion rather than in political freedom or organized industrial efficiency. Democracy is a spiritual power or product of a people.

Laski's phrase "a system of power" probably can not be achieved upon a democratic basis without the attitude of personal responsibility which Bailey describes. However our ideas of just what is democracy may vary, we hold to it as one of our basic ideals and as a large factor in social progress.

Half a century ago there was a general assumption that universal education was essential for democracy and that education would ensure a wise choice of officials and decisions of public policy. Although there has been a gain in this direction, the results have by no means fulfilled the hope of the political effect of the public school system. There are several reasons for this. First, education was too narrowly conceived as being a training which would give the individual intellectual tools for making a living; it tended to be individualistic. Secondly, although the idea of education for citizenship has been current for some years, for the most part it assumed that an intellectual understanding of certain facts of government would ensure the desired behavior. Only recently have educators learned that behavior is governed by feelings and attitudes more than by intelligence, and that these are developed through experience more than by rational thought. But even if education for citizenship in our public schools had been all that might be desired, it would not have enabled the present generation to deal with the problems of public policy with which it is now confronted. The fact is that changes in our environment occur so rapidly that it is impossible for education to anticipate the social and economic problems which will arise within the life of one generation. How can education anticipate the effects of such an invention as radio?

To-day the education of children and youth *for* life is not enough, for life is changing all the time. The educative process must go on *through* life. If parents are to be of any help in the educational process of their children to-day, they can not rely on what they learned in school or college, but they must be informed on the latest knowledge. Obviously we can not go to school all our lives, but it is possible to devise a system of adult education which will enable men and women to study current prob-

lems of all sorts so that they may gain accurate knowledge concerning them and form their own opinions, or that they may become convinced that some of these problems are subjects which can be solved only by experts.

Nor need this process of adult education be chiefly an affair of the schools or of the formal educational system. Much of the best work that is now being done in adult education is by extension work in agriculture and home economics through the farm and home bureaus, through university extension groups, through parent teacher associations, child study clubs, granges, and similar groups. In the next generation we shall have to have a very considerable increase of agencies qualified to give expert assistance in the promotion and guidance of such more or less informal study groups. Through such a system we might continue our education so that we could know whether to accept or reject new social inventions, and if we accept them, to participate in them in such a way as to make possible their success. Democracy and social progress can develop no faster than the education of the people, and to-day their education for the immediate problems before them can not be anticipated in the schools or colleges. Who could have foreseen before the world war that we should become a creditor instead of a debtor nation and that the collection of war debts would involve us in the present international situation? Yet having the situation, what means are there for effectively educating our adult population concerning these matters, which are not controlled as political propaganda?

Nor is this principle that education is essential for social progress peculiar to matters related to government. It applies equally to non-governmental organizations. For instance, the social invention which has meant most to agriculture is the cooperative marketing association. Where the membership has been educated as to the facts and principles of the business matters involved, powerful and sound organizations have been built up; but where the membership has been secured by emotional pressure and the members have been ignorant of the methods of their organizations and the technical issues involved, the organizations have been short-lived.

There is no magical formula for creating social progress any more than for building automobiles. The automobile is the product of vast amounts of scientific research and technical efficiency, by people who know. Social inventions which will ensure a larger degree of social welfare likewise depend upon the scientific research of the inventor and the technical efficiency of the operator, but the parts of the new organization are human beings in a new social relationship, and if these elements of the new invention are ignorant of the rôle which they must play in order that it may function, it is doomed to failure unless they can be educated to give intelligent participation.

As Laski has indicated, the achievement of Democracy depends upon the control of power and is indeed merely a form for the social control of power. Power may be generated and controlled with beneficient effect, as in the electric current which lights our homes, or it may burst forth malevolently, as does the bolt of lightning which carries destruction. Uncontrolled power results in social disorganization, whether it be by the anarchist's bomb or by the manufacturer throwing thousands of men out of work because it is more profitable for his stockholders to do so. The democratic form of power resides in an intelligent public opinion, in an understanding of social problems as a result of education and in an attitude of finding personal welfare in the common good rather than at its expense.

Certain types of social progress which depend upon the power of authority are

possible under absolutism, fascism or communism; but social progress under a democracy is dependent upon education.

V. Planning Social Progress

In addition to all these factors, a chief reason why social progress lags behind material progress is that the latter is planned, whereas social progress is largely a product of social reform, an effort to correct social maladjustments rather than to prevent them by foresight. To-day, there is a peculiar need for social planning because material progress changes the social situation and disrupts our established human relations so rapidly that human relations tend to drift in its wake.

After ably analyzing the causes of the disorganization of our national life and culture and pointing out that "the spiritual values of life are among the most profound of those affected by developments in technology and organization," the President's Committee on Social Trends concludes its summary report with a convincing plea for the necessity of social planning:

> The alternative to constructive social initiative may conceivably be a prolongation of the policy of drift and some readjustment as time goes on. More definite alternatives, however, are urged by dictatorial systems in which the factors of force and violence loom large. In such cases the basic decisions are frankly imposed by power groups, and violence may subordinate technical intelligence in social guidance.
>
> Unless there can be a more impressive integration of social skills and fusing of social purposes than is revealed by recent trends, there can be no assurance that these alternatives with their accompaniments of violent revolution, dark periods of serious repression of libertarian and democratic forms, the proscription and loss of many useful elements of the present productive system, can be averted.

Finally, it concludes:

> Fully realizing its mission, the Committee does not wish to assume an attitude of alarmist irresponsibility, but on the other hand it would be highly negligent to gloss over the stark and bitter realities of the social situation, and to ignore the imminent perils in further advance f our heavy technical machinery over crumbling roads and shaking bridges. There are times when silence is not neutrality, but assent.

These are courageous words not of radical agitators but of a committee of six of our most eminent social scientists appointed by President Hoover who form their conclusion from the studies of hundreds of the best social scientists in the country. Evidently there is immediate need of planning if we are to have social progress rather than social chaos.

What, then, should be the procedure in planning for social progress? I can but briefly outline the essential steps.

First, we must have the facts. This involves research in social science comparable to that now made in the physical and biological sciences. As yet we have but a few bureaus of municipal research and various research bureaus of state and federal governments, all of which are considerably hampered by political considerations. As such research in social science is for the benefit of all rather than for the few, it will need to be supported by public taxation or by private endowment, for one of the essentials of any valid social research is that it must be free. It is difficult to twist the facts of chemistry, for they can be verified by laboratory experiments, but the findings of social science are not so readily verifiable and are always subject to the social pressure of interested parties.

Secondly, we shall require social inventions based upon the discoveries of social science. The difficulty and importance of social invention has already been discussed.

Thirdly, we shall need a new process of adult education which will inform the people of the facts, which will enable them to make wise decisions in the choice of social inventions and which will make the success of these social inventions possible through the intelligent participation of those concerned in them.

Fourthly, we shall need a new definition of our objectives, a new conception of what is involved in such terms as "Democracy" and "Social Welfare," and a beginning at the resolution of the conflicting interests involved.

Finally will come a definite process of social planning which will seek to relate physical and social inventions to our probable future needs, carried on by groups of technical experts and by representatives of the various interests involved and of the general public. There is, as yet, no formula for social planning. The most important immediate step is to come to the conviction that social planning is necessary and to recognize that although mistakes will undoubtedly be made, it is possible to learn how to plan for social progress as well as for the improvement of our physical environment.

Social planning has already become an increasingly important phase of city and regional planning. Recent examples of planning are the land utilization survey of the State of New York as a basis for its reforestation policy, and President Roosevelt's Tennessee Valley Project, both of which involve social planning.

How far shall we go in planning for social progress? What shall be planned? Will social planning involve all phases of life? These are questions which can not be answered dogmatically. Wisdom would indicate a pragmatic procedure rather than following doctrinaire theories. We do not want the excessive regimentation of life involved when all life is planned, as under communism, but we must plan how to meet those maladjustments which now threaten social chaos. Such problems as unemployment, money, banking, agricultural marketing and the control of agricultural production, adequate health and medical care, a broader system of education for all ages and international relations are forcing us to social planning, whether we will or no. To what extent our planning will result in social progress will depend upon whether we utilize the best technical ability available and whether we are willing to pay the price involved in our own education so that we may give intelligent support to the plans which we will be called upon to approve.

There is no magical formula which will ensure social progress. The old adage, "If wishes were horses, all men would ride," is still true. Our wishes may be worthy ones, but we must have the horses. We must implement our desires, by making the same use of social science for social planning as we have used the engineer and the chemist in subduing a continent and creating modern industries. The age of pioneering is not past and there is more need than ever for a new type of individualism and personal initiative devoted to the common welfare. To-day's pioneering is in the field of social discovery and social planning, which will be as difficult and will require as much moral fortitude and heroism as was ever shown in conquering the primeval wilderness. Planning for social progress offers a challenge to our keenest intelligence, to our belief in human integrity and to our true patriotism. That the challenge will be met is indicated by the response which the American people are giving to competent leadership in the attempt to secure social progress through planning, through intelligence and good will rather than through the domination of power.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE ASTRONOMY OF NAVIGATION

By Dr. LORING B. ANDREWS

EXECUTIVE SECRETARY, HARVARD OBSERVATORY

For those of you who are located in the interiors of the continents of the world and whose experience on the waters of the earth has been limited to boating on small lakes, rivers, ponds, and the like, reliance upon celestial objects for a knowledge of your whereabouts has hardly been necessary. Familiar landmarks on the shore or wooded islets or partially submerged rocks are sufficient keys to the position of your craft. Those of you who sail the oceans of the world, with day after day on the open sea without sight of land, nothing but water beneath and sky above your vessel, rely usually upon the wisdom of the ship's officers to guide you safely from one port to the next. To a seafaring man, however, a constant knowledge of the vessel's whereabouts is of prime importance that he may reach his destination with promptness and certainty.

Once the shoreline drops below the horizon and the vessel's course is set for a destination, distant by many watery miles, the determination of the location of the vessel becomes an astronomical problem. One square mile of water differs from any other square mile of water only in minor characteristics such as temperature, apparent color, the presence of drifting weed or in the smoothness or roughness of the surface. Such criteria are, however, hardly conclusive evidence of the location of any particular square mile, for similar appearances are to be found in endless repetition over the water-covered surface of our planet.

But whereas two observers, one, say, on a vessel ploughing the North Atlantic steamship lanes, and the other bound south from Manila to Australia, might find but little in the appearance of the ocean waters to furnish a clue to their location, the appearance of the sky at the same instant for the two observers will not be the same. At any given instant the appearance of the sky from any point on the earth's surface is completely characteristic for that place; in one locality, the sun may be rising, in another setting, in a third, it may be night and the stars be visible; perhaps in one location it is the stars in Taurus which are rising, in another they may be setting, in a third they are overhead. If one then possessed a book of drawings that gave the appearance of the sky under all possible variations of time, day and place, one might find that drawing similar to the observed appearance of the sky for the given instant of the given day, and say that he was located in the latitude and longitude for which the drawing had been made. Quite obviously such a book must remain only a dream, yet the actual way in which the navigator determines the location of his ship is almost exactly analogous. The practical navigator finds that the simultaneous observation of the compass bearings of any two celestial objects, two stars, for example, and the measurement

of the distances they appear to be above the horizon are sufficient to indicate completely the appearance of the remainder of the sky and to determine the latitude and longitude of the ship at the moment the observations were made. Let us trace the procedure, using a numerical example.

Imagine that you are a passenger on a vessel steaming along the mid-Atlantic beneath a starlit October sky. At exactly 11 o'clock by your watch, which perchance is keeping correct Eastern Standard Time to the very second, you observe the bright star Capella to bear ENE and to be 49° above the horizon, and at the same time observe that blue-white Vega bears NW by W and is 19° above the horizon.

If, at the instant, instead of being on shipboard in mid-Atlantic you had been located in the Italian Alps near Mount Cervin, the star Capella would have appeared directly over your head, that is, in your zenith. You would then have been standing at the so-called sub-stellar point for Capella. If, for the nonce, the earth would cease its rotation and time in consequence cease to pass, as you proceeded away from this point in the Alps along the curved surface of the earth, Capella would appear gradually to sink toward your changing horizon. It may be easily shown that for every sixty nautical or sixty-nine land miles you traveled, Capella would drop 1°, until, having traveled a quarter way round the earth, you would find the star on your horizon. You have the choice of withdrawing from the sub-stellar point in any one of an infinite variety of directions, and, since the earth is, to all intents, a sphere, the distance you would find it necessary to withdraw to produce any desired result would in every case be the same. The locus of points from which at 11 P. M. the observed altitude of Capella would be the same is therefore a circle with its center at the sub-stellar point. This circle is called for self-evident reasons a circle of equal altitudes. From your ship in mid-Atlantic the altitude of Capella was observed to be 49°. To cause the altitude of Capella to reach this figure, you would find it necessary to withdraw from the sub-stellar point a distance of 2,560 nautical miles. On a large globe of the world then you might describe this circle and say that somewhere on the circle the ship must be. Of course you were not completely lost before you made your observation. You can easily restrict your choice of position on the circle to a small arc of it somewhere in mid-Atlantic and therefore draw only a small portion of the whole circle. This small portion is called a line of position for your vessel, an arc of a circle upon which your ship must lie.

Your one observation is obviously not conclusive. It does not tell you at which point of the line of position the vessel is located. However, at 11 P. M. you also observed from your ship that Vega had an altitude of 19°. Your ship must also lie on a second circle with center at the sub-stellar point for Vega and with an appropriate radius derived from the observed altitude, in this case 4,260 miles. It may be shown that at this instant the sub-stellar point for Vega was located approximately 1,300 miles due west from San Francisco. Again a small arc of this circle will suffice, an arc in the region in which the vessel is sailing, a second line of position. It should hardly be necessary to suggest that the two lines of position, the one from Capella, the second from Vega, will intersect, thereby designating the vessel's location and solving your problem. Such is the essential background to the method of determining by astronomical observation the position of a vessel at sea.

In actual practise the navigator of a

vessel represents these arcs by straight lines. This is a valid procedure, since the circles are so large that the small arcs used deviate but infinitesimally from straightness. Mathematically, the navigator computes the latitude and longitude of one point which is in the neighborhood of the ship's approximate location and is at the same time on the circle of equal altitudes. He also derives by mathematics the bearing of the object observed, for the orientation of the line of position through this computed point is always at right angles to this direction. The geographical location of the sub-stellar point is not necessary to the practical solution of the problem. Frequently a third line of position resulting from the observation of a third body is drawn to serve as a check against possible errors of observation.

As they appear to the eye the stars are most readily pictured for such problems as these, as located on the inner surface of a sphere, the celestial sphere, concentric with the sphere of the earth, and with an infinite radius. The exact locations of the stars, the planets, the sun and moon and other celestial bodies upon this inner surface has involved the astronomer's attention from earliest time and their relative locations are carefully and accurately recorded in nautical almanacs. The celestial sphere apparently rotates once every twenty-four hours about an axis coincident with a line passing through the north and south poles of the earth. The exact time of observation serves to fix the particular orientation of the celestial sphere upon its axis at the moment, and thereby to fix the geographical location of the sub-stellar points. Since the location of the circles of equal altitudes at any instant is in turn dependent upon the location of these sub-stellar points, the exact time of observation is clearly essential to the solution of the problem.

For the purpose of determining this time accurately all ships carry at least one accurate timepiece, called a chronometer, which is an exceedingly carefully constructed clock mounted in gimbals so that it will maintain a constant horizontal position regardless of the roll and pitch of the vessel. It is commonly found that a change in the orientation of a timekeeper changes the rate at which it gains or loses. Due to its stability the rate of gain or loss of a chronometer is usually very constant, so that its error at any time may be computed from any previously known error. In these days of radio, however, the radio time signals make the need for such an excellent timekeeper somewhat less important, for the error of a less accurate timepiece may be determined many times during the day. It is interesting to note that the source of the correct time which is broadcast is astronomical, for upon direct observations of the stars from an observatory with known geographical location is based our knowledge of time.

Those of you who are familiar with the practise of navigation at sea realize that not all observations for position are made at night. The sun furnishes by day a very convenient object, more easily observed than a star. Any one observation of the sun provides of course but a single line of position even as an observation of a single star provides but a single line. One observation of the sun is, therefore, not conclusive of the vessel's position. It is common practise to observe the sun, firstly, if possible, when it is due east, secondly, when it is due south and, thirdly, when it is due west. A suitable combination of the lines of position derived from these three observations separated in time, two of them running north-south and the third east-west, will give both the latitude and the longitude of the ves-

sel at any instant during the daylight hours.

Of course a ship at sea is no more bountifully provided with clear days and nights than is the average point on land and frequently many days pass without a view of celestial objects. The navigator's problem then is hardly astronomical. It involves rather a strict attention to the courses which the vessel sails and to the distances run. Knowing the point of departure of the ship subsequent positions are found in exactly the same way that you would find a street in a city upon being told that it was three blocks north and two blocks east from your point of inquiry. It is a process known as dead reckoning and is always used to fill in the gaps between positions which are determined from celestial observations.

Should you then ever travel the oceans of the world for the first time or in repetition of many an earlier ocean voyage, look aloft at the sun in an azure sky and at the star-studded vault of night and realize that these heavenly bodies are your friends and guides. Remember that on the bridge of your stout ship are the officers who know the ways of observing these objects and computing the vessel's whereabouts and where over the horizon lies the next port of call. Remember that in the observatories of the world astronomers night by night compile the reference data and determine the correct time so necessary to the solution of the problems of navigation. Wherever you sail, remember that the vessel is headed on her course to the best knowledge of those in command, and, in every case, *un bon voyage.*

MAPPING FROM THE AIR

By Professor S. S. STEINBERG

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While it has always been man's ambition to view the world from the air as does the eagle, the modern engineer has found in human flight the opportunity to survey and map large areas of the earth's surface at great savings in time and cost. The value of pictures from the air was first appreciated and investigated by European engineers in the latter part of the nineteenth century. Early experiments were made by using kites and balloons. The introduction of the dirigible stimulated these attempts, and finally the development of the airplane made apparent the great advantage of its use as an aid to surveying and mapping. This advancement in engineering grew out of the world war when it was extensively used for military purposes. It has been estimated that during the last years of the war 80 per cent. of the information about the enemy was obtained by aerial photography. Since the war, aerial surveying has been used as an aid to the map-maker in supplying certain kinds of detail much more faithfully than a surveyor could sketch them even by covering the terrain very closely.

The inherent characteristic of an air map is accuracy. Combined with the vivid and complete detail of the ordinary photograph is the record of true relations among the features on the ground. Houses, cultivated fields, fence lines and wooded areas are all shown in their proper proportion. An air map is a permanent and complete record, as the camera's eye misses nothing.

An aerial photograph is not a map, but a perspective view in which direc-

tions and distances may be somewhat distorted. A photograph of absolutely level ground taken with the axis of the camera truly vertical approaches a map in accuracy. If there is any appreciable relief in the ground or appreciable tilt in the camera, the images on the photographs are displaced from their true positions. However, the photographs are still usable and by employing certain graphic and instrumental methods map construction can be expedited tremendously.

Successful flying over an area for the purpose of mapping calls for skill on the part of the pilot and a thorough knowledge of the use and care of the camera on the part of the photographer, with fine teamwork between the two. Experienced airplane pilots consider air mapping the most difficult kind of flying. Traveling at a speed of 100 or more miles an hour in the thin cold air at high altitudes, with eyes concentrated on the instrument panel to maintain a straight course, with wings level, is a constant strain on the pilot.

Most of the flying is done at altitudes as high as two or three miles above the ground. Below 7,000 to 8,000 feet the air currents are full of gusts and bumps which render the results unsatisfactory, while at altitudes as low as 3,000 to 4,000 feet accurate air mapping is quite impossible.

As the plane ascends, the temperature of the air drops rapidly, on the average about one degree for each 300 feet of ascent. At altitudes of 15,000 to 20,000 feet, at which most of the flying for mapping is done, the air is piercingly cold even in midsummer, being 50 to 60 degrees lower than on the ground. For flying above 21,000 feet oxygen tanks are necessary for pilot and photographer. Aerial photographs have been taken from altitudes as high as seven miles.

With a given mapping project in view, a guide map is prepared with flight lines on it to enable the pilot of the plane to cover completely the area to be mapped. By comparing the objects on the guide map with those on the ground the pilot is able to fly in straight parallel courses back and forth. Accurate aerial surveying requires an airplane that is reliable, sturdy and powerful, one that is capable of sustained flight at all altitudes, that can rise and descend in small fields, that can fly true to line and that is economical of fuel. The altitude at which the plane should fly in order that the photographs may be made at a predetermined scale is dependent on the general elevation of the country and the focal length of the camera lens. Practically cloudless weather is necessary to secure good aerial mapping photographs. In most of the United States only one day in seven can, on the average, be depended upon for such work.

While the first aerial photographs were taken with a single lens camera, the U. S. Geological Survey, during the world war, designed and constructed in cooperation with the National Research Council the first experimental three-lens camera which permitted taking vertical photographs from the air, each exposure of which covered a wide area along the line of flight. The next development was a four-lens camera by army engineers, which was followed by a five-lens camera, and the latter is now used for standard aerial mapping in the army. The five-lens camera is constructed with the axis of the central lens pointing vertically downward with the four other lenses grouped symmetrically about the central lens and at constant angles from the axis of that lens. After the oblique photographs taken by the four side lenses are transformed to horizontal planes and assembled with the central photograph, the result is a composite pic-

ture shaped like a maltese cross. This camera is designed exclusively for small-scale mapping and permits covering an extremely large area in a single exposure. For example, a flight at 18,000 feet altitude results in covering a strip 18 miles wide. On a recent project in Maine, 3,500 square miles were covered in three hours by 160 exposures.

The ultimate development of the multiple lens camera idea seems to lie in a nine-lens camera which will fill the gores between the four oblique lenses and present a complete picture covering an entire area at a single exposure. A German nine-lens camera has already been developed and is designed largely for exploration work. It can cover an area of 200 square miles at a single exposure from an altitude of 16,000 feet. A nine-lens camera has been developed in the United States, but expense of manufacture has postponed its production.

The aerial mapping camera is of rigid all-metal construction and points straight downward through a special hole in the bottom of the plane. It is so suspended in a gimbal mount as to permit the optical axis being kept vertical, regardless of the oscillations of the airplane. It is not a motion-picture camera, but takes still pictures 7 by 9 inches in size, at any desired time interval. It is operated either automatically or by hand. Generally, successive exposures are made from 10 to 15 seconds apart. The film is 75 feet long, sufficient for making 110 exposures. The film holder may be quickly removed and replaced with another magazine, thus making it possible to secure a very large number of exposures in the course of one flight. The shutter is capable of opening and closing in the 150th part of a second. With its various accessories, the camera weighs about 50 pounds.

The photographer times the successive exposures so that they overlap each other like shingles by about 60 per cent. in the direction of flight and about 50 per cent. sidewise in successive flights. The overlap makes it possible to use only the central portion of each photograph, which alone is in true vertical projection. The overlap, moreover, allows stereoscopic study of the terrain.

One of the most interesting and most important developments in mapping from the air is the stereoscopic use of aerial photography. The interpretation of aerial photographs is much easier when overlapping prints are examined stereoscopically. The instrument used for this purpose, though much larger and more complicated, is based upon the same principle as the once familiar parlor stereoscope. This instrument has the peculiar property of causing the photographic image to be seen in a third dimension, namely, that of relief, with the hills standing out above the valleys, and the houses, trees and other objects strikingly visible in three dimensions. The practical advantage of stereoscopic vision to the engineer is that, with suitable mechanical devices, he is able to draw from the photographs contour lines, which are lines of equal elevation and are of great value in the study of any proposed engineering project. In making topographic maps from aerial photographs of Zion and Bryce Canyon National Parks in Utah, the U. S. Geological Survey used a stereoscopic instrument, with a resulting saving of about 50 per cent. in time and 30 per cent. in cost.

Aerial photographs have been utilized for many purposes. They have been found of value in city planning and zoning, in studying highway traffic problems, for irrigation and water supply projects, for river and harbor development, flood control, timber estimates, geological study and tax assessment purposes. Middletown, Connecticut, was the first municipality to be revalued by an

aerial survey. As a result, nearly 1,900 buildings were discovered which had previously escaped taxation.

Aerial mapping is preeminently useful in surveying difficult and inaccessible country. Low-lying swamps and coastal areas can be mapped adequately by no other method. The U. S. Coast and Geodetic Survey has used aerial surveying extensively, in conjunction with its ground control, in mapping the complicated coast lines of Florida, Louisiana and the Pacific region.

Air mapping is employed by the United States Army wherever it is practicable. It is now engaged in mapping from the air part of the Olympic peninsula in the state of Washington, a region of heavy rainfall, dense forests and rugged topography. The largest single aerial mapping job done by the army during the last few years was that of mapping for the purpose of flood control practically the entire alluvial valley of the Mississippi River from Cairo, Illinois, to the mouth, an area of more than 50,000 square miles. In addition to the government agencies mentioned, there are several commercial firms that are splendidly equipped and are doing excellent work in the field of air mapping.

The mapping of the United States has gone forward since the early days of discovery and settlement, and particularly as a result of the efforts of such government agencies as the Coast and Geodetic Survey, during the more than 100 years of its existence, and the Geological Survey during the past 45 years. Yet to-day only 25 per cent. of the area of the country is adequately mapped, and more than half of the United States has never been mapped, even in the crudest way. At the present rate of progress it will take almost a century to complete the basic map of the United States. While mapping from the air will never replace ground surveying, it will serve to expedite the production of maps so urgently needed for national planning, public works and the general welfare.

WHEN THE PAST BROKE ITS SILENCE

By Dr. E. A. SPEISER
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If we were granted a leave of absence from the present for a brief vacation in the past, to what distant period would we turn for a change of historical scenery? Many have posed this question, in one form or another, and the answers recorded range over a long stretch of time. The individual choices depend entirely on what our privileged travelers may be interested in and on how much they may know about the age which they would thus favor. Havelock Ellis, *e.g.*, admits in one of his essays that the thirteenth century of the present era would have suited him admirably for such a purpose. Others have hastened to reserve vantage points in ancient Greece and Crete, Palestine and Egypt. We may feel certain that India and China have found numerous bidders and that, in fact, scarcely a spot on the globe or a moment in the progress of mankind has been neglected in this revealing intellectual pastime.

There is, however, another small portion of the ancient world which is destined, I believe, to attract an ever-increasing volume of this rather unusual tourist traffic. The region in question is Mesopotamia, and the time is

the end of the fourth millennium B.C., or just about five thousand years ago. And the reason for this long-range attraction? We have here a juncture at which we are in a position to witness an event that is unique alike in importance and in interest. For what is about to take place is man's first appearance upon the stage of history. For countless millennia—anthropologists now compute the period at more than a million years—primitive man had been advancing towards this particular goal. There had been an all but timeless era of groping. Even the comparatively recent age of what we now term prehistoric civilization was very long in fulfilling its course. But at last the apprenticeship is completed, the stage set. Modern life is ready for its debut. How did the event come off? If we time our visit judiciously we may be able to view not only the dramatic feature itself, but also some of the back-stage preparations as well as the immediate effect of the performance on the contemporary audience. In other words, how was history ushered in, what were the principal factors behind the changes involved and how was life affected by these happenings?

Excavations conducted within the past ten years have furnished the answers to these questions. Before we proceed with the account, however, it will be well to consider for a moment the essential difference between prehistoric and early historic times. Where do we draw the line and with what justification?

Prehistoric man is known to us from a vast mass of material remains. By the end of the Late Stone Age he had developed a high civilization which is reflected in his tools and vessels, his art and architecture, and in the nature and manner of his worship. Some of his finest products have never been surpassed. These notable achievements are by no means sporadic or accidental. They are the direct outcome of a long and continuous advance in which numerous groups played vital rôles. The steady development of late prehistoric civilization can now be followed through some twenty successive stages represented by as many occupations or strata superimposed upon one another. Such uninterrupted sequences of settlements have been found, for instance, in Erech in the south and Tepe Gawra[1] in the north of Mesopotamia, to mention only two notable instances. It may be added that parallel sequences, though not nearly so complete, have been brought to light in Persia, Asia Minor, Syria, Palestine and Egypt. And yet, despite this impressive succession of archeological generations, the people of that age remain shadowy and anonymous. We may admire their work and appreciate their talents, but we are doomed to remain in ignorance as regards their racial affiliations, their speech and the identity of their rulers and artists. To us they are indistinct and inarticulate; in short, they are prehistoric.

It follows that in order to be classed as historical a given period must be articulate; and to be articulate it must be literate. It should be able to convey its message to posterity not only through the medium of material remains, but also by means of written records, thus placing an effective check upon the impermanency of time. When we learn, *e.g.,* that the first independent ruler of the city of Ur was a certain Mesannipadda, that the language he spoke was Sumerian, that he made war on the people of Erech and gave costly presents to his wife, whom he mentions by name, we realize at once that quiet and anonymity have departed forever and that

[1] *Cf. The American Journal of Archaeology,* 36: 462–471, 1932.

history is upon us in full sway. It all began the moment the past had broken its silence.

Having discovered what it was that first made history, we may now assign to this event a reasonably accurate date. We have seen that the unbroken story of Mesopotamia's past begins in the Late Stone Age. From then on successive settlements in sites soon grown into tall mounds take us up step by step far into the Age of Metal. In the course of this ascent we have an ideal opportunity to study the progress of writing. The first signs, in the form of crude and obscure pictographs, are encountered after some fifteen steps or strata have been left behind. From these modest beginnings a complete system of writing is evolved within a few hundred years, and this evolution is accomplished at close to 3,000 B.C. The beginning of history proper dates, therefore, from that time.

But is the difference between prehistory and history merely a question of more or less successful scribbling? Was life in general much the same on both sides of that divide? Decidedly not. The contrast between the two ages that face each other across the flimsy borderline of a few decades is so sharp and distinct that nothing like it is seen again until we get down to within earshot, so to speak, of our own times. This brings us to the other vital element in our story —the coming of copper.

As we have seen, the Near East had an advanced culture centuries before that time when some unsuspecting genius presented mankind with a long memory by having hit upon the idea of writing. Your Mesopotamian or your Egyptian of the fourth millennium B.C. can hardly be mistaken for an insensitive barbarian. He built temples which arouse our envy and admiration by the symmetry and simplicity of their design. His carvings on plaques and seals were animated with an unending variety of amazingly lifelike scenes. Hard stone was transformed into graceful beads and amulets, and even the fragile ceramic fabrics showed in their decoration the delicate and imaginative touch of the artist. Such economic necessities as flint and obsidian, which were required for the manufacture of tools and implements, could apparently be had for the asking. Life appears to have been peaceful and leisurely and on the whole uneventful.

When copper first found its way into the principal centers of the ancient world, late in the prehistoric period, no one could have suspected that the first great industrial revolution would be made of just this sort of reddish stuff. To the craftsman who hammered it into shape the metal was merely a costly substitute for stone; a rarity and nothing more, incapable of disturbing the even tenor of contemporary ways.

But at length the discovery was made that when the metal had been reduced and then remelted, it could be cast so as to yield any desired shape. Unlike the rigid stone, copper became pliable and strangely responsive. In other words, some one had finally stumbled upon the basic principle of metallurgy.

The rest is a matter of history in more ways than one. The discovery opened up vast horizons, and it was not long before the established order of things was completely upset and out of date. Event followed upon event with alarming rapidity. Home industries received a powerful impetus and foreign contacts acquired a new meaning. Stone-users were no match in battle with the wielders of the new copper weapons. Possession of the metal became a stark necessity and, since the known mines were limited in number and restricted to a few locations, there was a mad scramble to control the sources of supply. Dis-

tances were disregarded in the search for new deposits. In the heat and dust of this upheaval whole nations were shifted and transplanted almost over night. When the smoke had at last cleared it was an entirely different world that faced the unknown future; a restless world, constantly on the move. And when did life assume this dynamic character? By a coincidence that may not be altogether remarkable, shortly before 3000 B.C.

This, then, is the picture restored from a few old and long-inhabited sites of Mesopotamia. You can not mistake its main outlines once you have been fortunate enough to find and excavate such a place. An excellent example of one is Tepe Gawra, near Mosul, Iraq, which I had the privilege to explore for the joint expedition of the American Schools of Oriental Research, the Dropsie College of Philadelphia and the University Museum of the University of Pennsylvania. First you are impressed by the beauty and restraint of the prehistoric civilizations. Then you reach a point where these come to an end. A few feet of earth, and you have ascended to a different world. Across that enormously significant border are the foundations of modern life; great wealth and industry and skill, and with it all a feeling that everything is somehow in a state of flux. And the ground is literally green with copper.

Thus writing and metallurgy, or literature and industry, in a somewhat incongruous alliance, combined to usher in history. The profound revolution which these factors brought about is without analogy for thousands of years. It is not until we come down to the beginning of the last century and note the changes wrought by the advent of the Steam Age that we find anything comparable in magnitude. This parallel is more complete than appears at first glance. But we must not tell the whole story, or there would be no point to the trip that we spoke about at the beginning. So if that cosmic opportunity is still open to you, and if you can tear yourselves away for a while from the excitements of the present, won't you book passage for Mesopotamia at 3000 B.C.? Or would you rather have a less stirring vacation?

INTERPRETING SCIENCE TO THE PUBLIC

By L. N. DIAMOND

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In the introduction to the collected works of Robert Boyle, the distinguished English scientist of the seventeenth century, appears the following:

> He endeavors to make all things he treats of plain, easy, and familiar. There is no deep knowledge of mathematics or algebra requisite to understand him fully. . . . What principally recommends our author and distinguishes him from the vulgar herds of chemists, naturalists, and philosophers is this humane temper, this candid, generous disposition, this wide learning; the whole seasoned with much wit and style.

And when one opens the pages of Boyle's works, one can not help being impressed with the fluent and lucid style in which his numerous discoveries are expressed. Certainly, the writings of many contemporary scientists would suffer by comparison; at least in the mind of the lay reader.

One need not seek very far for the explanation. Scientists, as contrasted with the man on the street, speak another language. The layman finds the jargon of scientific circles unintelligible; strewn with the boulders of technical formulae; abounding in steep precipices of outlandish vocabulary which lead the unwary to a dismal end. Unacquainted as he is with the quantitative techniques increasingly used in research, he shies away from the abstruse formulae which scientists use as a matter of course.

However, the point can not be sufficiently reiterated that effective adjustment to the world in which we live is conditioned by the extent of our acquaintance with its phenomena. It is as true to-day as in Huxley's time that our lives and fortunes are the stakes in a game of chess of which the world is the chessboard, the pieces are the phenomena of the universe and the rules of the game are the laws of nature. Scientists to-day are engaged in the task of creating a world vastly different from that of our grandfathers, and the necessity arises of assimilating their discoveries upon as wide a social scale as possible.

Unfortunately, experience has amply demonstrated that we can not leave the task of assimilation to the scientist. Rarely, indeed, is he equipped with the ability to translate his discoveries into the language of the street. For every investigator who has succeeded in writing effectively for the press and in carrying on creative research at the same time, there are hundreds of others who have made the discovery that science is an exacting mistress who brooks no dalliance with the newspaper. True, there have been scientists, such as the late Sir E. Ray Lankester, whose delightfully informal style is one of the glories of English journalism and whose impressive volume of discovery is one of the glories of biology. Nevertheless, this combination of the two abilities is a rare one, and in our age of specialization it appears that the interpreter, equipped with a special training and technique, is necessary as the liaison officer between the scientist and the layman. Of the crucial need for the interpreter none has written better than Glenn Frank, president of the University of Wisconsin:

> The future of America is in the hands of two men—the investigator and the interpreter. We shall never lack for the administrator, the third man needed to complete this trinity of social servants. And we have an ample supply of investigators, but there is a shortage of readable and responsible interpreters, men who can effectively play mediator between specialists and laymen. . . . A dozen fields of thought are today

congested with knowledge that the physical and social sciences have unearthed and the whole tone and temper of American life can be lifted by putting this knowledge into general circulation. But where are the interpreters with the training and willingness to think their way through this knowledge and translate it into the language of the street. I raise the recruiting trumpet for the interpreters.[1]

In recent years, there has been a steadily increasing recognition of the need for a systematic program of publicity on the part of institutions devoted to scientific research. For one thing, the depression has driven home the point that the support of these institutions depends in large measure upon the good will of the public. Now that the Croesuses who gave so generously have been compelled to tighten their purse strings, scientists have realized that the confidence of the community in their work is requisite for adequate support of their programs. Certainly the need is great. As Watson Davis writes:

The pinch of scientific research hunger is being felt, illogically and cruelly. Take the Federal Government, for instance, rightly one of the principal supporters of science. In a typical year (1932) about $40,000,000 was spent upon the wide-flung and highly profitable scientific research activities of Uncle Sam. That is little enough. It pays dividends that make the conventional 6 per cent. look insignificant; demonstrable dividends that run from 100 per cent. to 1,000 per cent. per year on the money invested being frequently obtained in scientific research. Yet Uncle Sam is spending less than $29,000,000 this fiscal year on scientific research and millions of dollars of research funds were carved off the Federal budget in the name of economy since March 4th. The same sort of story is being enacted in universities, foundation-supported laboratories and in industrial concerns.[2]

A most ambitious program for the interpretation of science is that of Science Service, located in Washington, D. C. Founded by the late E. W. Scripps in 1921, it represents such well-known organizations as the National Academy of Sciences, the National Research Council and the American Association for the Advancement of Science. A tremendous debt is owed the late Dr. Edwin E. Slosson, the first director of Science Service. He was extraordinarily successful in clothing the dry bones of science with the flesh and blood meanings of the man on the street until his unflagging enthusiasm and devotion to his work resulted in his death.

His work has been carried on most effectively by Watson Davis, the present director. Under his direction, Science Service is pioneering in new fields; phonograph records of talks by eminent scientists are offered to schools, manuscripts are edited, revised and criticized for publishers, and science news talks prepared by eminent scientists are broadcasted weekly over a nation-wide network. However, Science Service is best known for its numerous syndicated press releases which are offered to newspapers on a non-profit making basis. Examination of these releases gives one an impressive picture of the struggles of scientists on the frontiers of knowledge on every part of the globe, inasmuch as some 350 scientifically competent correspondents report to Science Service from practically every world capital.

Unfortunately, neither Science Service nor any other organization devoted to the publicizing of science seems to give much attention to the valuable mass of knowledge of the past; knowledge of crucial importance in understanding contemporary developments. In consequence the gains of knowledge of the past must remain embalmed in the pages of the text-book. However, this is the advice Dr. Slosson gave would-be interpreters of science:

Don't think that because a thing is old to you it is known to the public. Many of your readers are still living in the nineteenth century; some of them in the eighteenth. Anything new

[1] Glenn Frank, *School Science and Mathematics*, 24: 5, 459, May, 1934.

[2] Watson Davis, unpublished address delivered before the North Carolina Press Association, Chapel Hill, N. C., January 19, 1934.

to your readers is "news" to them if hung on a timely peg.[3]

Many newspapers have made vast strides in the presentation of scientifically accurate science. It is no longer necessary to tie every scientific article to a fundamental passion or to resort to witchcraft in its explanation. During the past few years there has been a welcome shortage of such hardy perennials as telepathy; cancer "cures"; whiskey as a cure for snake bites; marking of children by experiences of mother before birth; living "missing links"; perpetual motion and others too numerous to mention. Dr. Austin H. Clark, who has done invaluable work in educating newspapermen as press representative of the American Association for the Advancement of Science, is of the belief that reporters are less facetious and more accurate in reporting science. He writes:

> At all scientific meetings there are likely to be a few young reporters who drop into the press room for the purpose of picking up a story. Having only the vaguest ideas about science, they are at a loss to understand what the meeting is all about. But they must produce the necessary copy. So they take refuge in ridiculing or distorting the proceedings. Aggravating as this is to the victims, any attempts to exclude such reporters, or to have them reprimanded, would only make matters worse. The only way to achieve results in press relations work is to show appreciation of the good work done, and ignore the bad. It is a pleasure and a source of the greatest satisfaction to be able to say that difficulties from this source, which were numerous and trying to the patience a decade ago, have now almost entirely disappeared. Even the youngest, greenest and cubbiest reporter now takes science seriously.[4]

While the press and other organs of publicity are disposed to cooperate with agencies seeking to interpret science, the total of scientific news appears to be amazingly low. The writer clipped and measured scientific articles appearing in four newspapers having the widest circulation in Washington, D. C., and two newspapers in New York City from May 12 to August 28, 1934. Excluding the Sunday editions, an average of only 2.4 articles pertaining directly to science with a total length of 13.6 inches appeared in each paper daily. This small figure requires further analysis as to the extent of each science contributing thereto over a much longer period.

Research workers, it must be admitted, have barely tapped this rich field of scientific interpretation in the press. Charles W. Finley and Otis W. Caldwell made a promising start in their study, "Biology in the Public Press."[5] These two investigators carefully examined the issues of 17 prominent newspapers for the months of June and November, 1921, in an effort to ascertain the type and amount of scientific materials appearing in them. However, their work needs to be repeated so as to bring it up to date. Moreover, a long-time investigation—over a ten-year period, let us say—would give us a more adequate basis upon which to modify our scientific curriculi on all educational levels. As Finley and Caldwell suggest, since these types of knowledge are going to the public in such large quantities all over the country, they surely reflect genuine needs and interests which should be taken into consideration in constructing courses of study.

The radio is a further untapped field of investigation. However, in comparison with the press, it fairly bristles with difficulties. For example, most stations keep incomplete records of educational broadcasts; in all too few instances are copies of scientific talks kept in their files. Some idea of what has been presented can be obtained from bulletins

[3] Edwin E. Slosson, unpublished mimeographed instructions for correspondents of Science Service.

[4] Austin H. Clark, "Science and the Newspapers." Unpublished.

[5] Chas. W. Finley and O. W. Caldwell, "Biology in the Public Press," Lincoln School of Teachers College, 1923.

announcing forthcoming programs which stations send to newspapers if one is willing to make a rough guess as to the content of a talk with only a brief title as a guide. And, as Dr. Cline M. Koon, specialist in education by radio of the United States Office of Education, informed the writer, it is not a rare occurrence for broadcasters to change their minds and speak upon a different topic than that announced in the newspaper.

There have been a good many interesting developments in interpreting science to the public by means of the radio which deserve wide publicity and dissemination. The Columbia Broadcasting System, in its School of the Air, stresses the value of informal discussion between the expert and the layman, as contrasted with a monologue by the former. Actuality broadcasts are being used on an increasing scale. By these are meant the broadcasting of important events at the time of their occurrence. An example is the recent talk by William Beebe from his bathysphere off the coast of the Bermudas. Beebe was an exceptionally fine broadcaster and those listening felt in a most tangible fashion the confining walls of the diving bell as it was lowered from the surface water a half mile.

But here again, he who would interpret science by means of the radio has very little to guide him. Research is needed as to the interests of the radio public as well as their scientific background. Scientists need instruction as to the proper technique of writing and delivering a talk. Broadcasters often point out that the scholar is often an absolute failure on the air because of his inability to translate the language of science into the language of the street, the market-place and the home. Not enough effort is made to motivate talks in terms of fundamental human experiences and emotions. Nevertheless, scientists are learning rapidly. Here is what Austin H. Clark, curator of echinodermata in the United States National Museum, writes:

> In a radio talk the opening paragraph must include something sure to interest the listener so much that he or she will continue to listen. For instance, suppose that I am giving a talk on "The Cow-bird" and I begin, "Our cow-bird, like most cuckoos, the honey-guides of Africa, some weaver-finches, some hang-nests, the rice-grackle, and a South American duck, and according to recent information one of the paradise-birds, lays its eggs in the nests of other birds which hatch these eggs and raise the young," the number of listeners will be reduced to the vanishing point long before I have reached the end of the sentence.
>
> In the first place, the title—"The Cow-bird"—is too grimly prosaic and means nothing to most people. In the second place, the long string of wholly unfamiliar names of foreign birds would cause the mind to skid unpleasantly and finally to run off the road entirely.
>
> But if I change the title of the talk to "Abandoned Bird Babies" and begin "Those unfeeling mothers who leave their little babies upon the door-steps of prosperous people's houses have their counterparts among the birds," etc., I shall be able to follow it up with a very considerable amount of information.[6]

There is an especially pressing need in these times for responsible interpreters who can make the public critical of the pseudo-science that raucously issues from the radio and other media of publicity. Charlatans, using science solely as a catch-word to victimize the consumer, utilize the vocabulary of laboratory to sell their products. Certainly, in these times of depression, the necessity for truthful interpretation is especially urgent. To-day, magazines that have done much to improve the quality of national advertising have begun to stretch a point or two to admit advertising of products whose worth is questionable. As Rexford G. Tugwell, Assistant Secretary of Agriculture, writes:

> Believing some of the advertising they hear by radio and read in public newspapers, people to-day are using dangerous fat-reducers and are

[6] Austin H. Clark, THE SCIENTIFIC MONTHLY, 35: 352–353, October, 1932.

thereby impairing their health; they are using depilatories with dangerous drugs and are being sent to hospitals; they are using "safe" hair dyes only to get lead poisoning for their trouble and money; they are taking radium water and are breathing their last; they are trying to cure colitis with a common laxative sold at a fancy price; they are trying to treat stomach ulcers with worthless nostrums and if, in despite of the nostrum they get well, they sit down and write testimonials for the manufacturers.[7]

The motion pictures can not be ignored in a study of the interpretation of science. Certainly such films as "Arrowsmith" or "Bring 'Em Back Alive" are remarkable in their accurate delineation of scientific techniques. News reels have also done splendid work in this connection; witness, for example, the splendid work of the cameramen in filming the casting of the 200-inch mirror for the world's largest telescope at the Corning Glass Works.

Museums, also, have done wonders in interpreting science to the public. Among the many promising innovations of museums is the nature trail of the American Museum of Natural History at Bear Mountain, New York. Here, scientists have transformed fern-filled glades, swamps and often fields into an open-air school where the students—mostly young men and women of 18 to 25 from crowded New York City—are taught, not by the stuffed, glassy-eyed effigies of the museum shelf, but by the living, refreshing creatures of the open.

The coal-mine completed recently at the Chicago Museum of Science and Industry is almost breath-taking in its reality. But one thing was missing when the mine was opened to the public and scientists rectified that when they gave the mine a correct "earthy" smell by means of chemicals.

The Museum of Science and Industry, recently opened in New York City, is one which has recognized the fact that moving things attract attention. And so one finds gadgets everywhere which whirl or whizz or boom upon pressing a button. There, science is no cold abstraction to be approached with reverent awe. Eager-eyed youngsters swarm into the model airplane and manipulate the "joy-stick," or press a button and watch a model of the new stream-lined train racing a locomotive of the vintage of 1825. Visitors are scrutinized by keen-eyed investigators, and their paths from one exhibit to another are charted in an effort to determine the "eye-appeal" of the exhibits. The tempo of this dynamic museum is prestissimo and the results of an investigation of its successful practises which the Carnegie Foundation is undertaking may do much to vitalize current museum practises.

Zoos, also, are beginning to see the light! The Zoological Park at Washington, D. C., under the able direction of Dr. Mann, has done admirable work in labelling the exhibits in the new reptile house so that they actually say something of interest to the layman. An exhibit which has attracted much attention is that of famous birds of poetry. These include the nightingale, skylark, chaffinch and the old-world robin redbreast. Would that some botanical garden might take the hint and have an exhibition of famous flowers of literature. Surely it would not be very difficult to secure specimens of a "red, red rose" or a "flower in the crannied wall"!

A most important phase of interpretation is that of departments of science connected with educational institutions such as high school and university. Up to now the bulk of publicity in the press has been secured by our higher institutions of learning. R. E. Garlin, analyzing a total of 15,047 column inches of educational news in Texas newspapers, discovered that 7,776 column inches, or more than 50 per cent., was devoted to the college; 1,395 column inches, or 19

[7] R. G. Tugwell, "Advertising and the New Food and Drugs Bill," Mimeographed News Release, Department of Agriculture, Pure Food and Drug Administration, September 16, 1934.

per cent., was devoted to the high school; 575 column inches, or 8 per cent., was devoted to the elementary school and 1.7 per cent. to the kindergarten.[8]

In all these schools, there is to-day an especial need for a relationship between the school and its patrons based upon mutual understanding of each other's needs. Interpretation is essential in the task of creating an informed public opinion favorable to the support of any legitimate educational function. We must learn to deal more realistically with those forces in society which, in the name of a false economy, are throttling all forward-looking innovations in science teaching. A twofold task lies before us; first, of visualizing a finer and more authentic picture of the rôle of science in our civilization and, second, of convincing the patrons of the public school and university through an intelligent and vigorous campaign in the press and radio that only by permitting us to fulfil that vision in our teaching can we help discharge the age-old obligation which the older generation owes the younger. Needless to say, it is the first task which is the more difficult, since it is part of the American tradition for citizens to have faith and confidence in the work of their teachers. Nevertheless, we must be prepared to justify our work in the press and other media of publicity so that the public will listen to us in the face of vociferous demands for penny-pinching economy on the part of a powerful and hostile minority.

LETTERS OF ALFRED RUSSEL WALLACE TO LESTER F. WARD

By Dr. BERNHARD J. STERN

DEPARTMENT OF SOCIAL SCIENCE, COLUMBIA UNIVERSITY

IN his autobiography Alfred Russel Wallace, codiscoverer with Darwin of the theory of evolution, speaks of the intimacy that developed during his tour of the United States between him and Lester F. Ward, dean of American sociologists, at that time serving as government paleobotanist in Washington. In the following paragraph he reveals their divergent views:

> As soon as the earliest flowers appeared he [Ward] took me on Sunday walks in the wild country round Washington our first being on February 13 [1887], through the stretches of virgin forest called Woodley Park, now, I believe, a botanical and zoological reserve, where many interesting plants were gathered to send home. . . . During these excursions we had many long talks and discussions while taking our lunch. At that time I was not a convinced Socialist, and in that respect Lester Ward was in advance of me, though he could not quite convince me. He was also an absolute agnostic or monist, and around this question our discussions most frequently turned. But as I had a basis of spiritualistic experiences of which he was totally ignorant, we looked at the subject from different points of view. . . .[1]

Wallace had for many years been interested in land nationalization, but he was influenced by the individualistic teachings of Mill and Spencer, and, as he put it, "the loudly proclaimed dogma that without the constant spur of individual competition men would inevitably become idle and fall back into universal poverty." Later, in 1889, after reading Bellamy's "Looking Backward," he publicly declared himself a socialist, which he defined as "the volun-

[8] R. E. Garlin, University of Texas Bulletin, No. 3044, p. 19, November 22, 1930.

[1] Alfred Russel Wallace, "My Life: A Record of Events and Opinions," 2 vols. Vol. II, pp. 117–18. New York, 1905.

Photo from "My Life" (Dodd Mead, 1905)

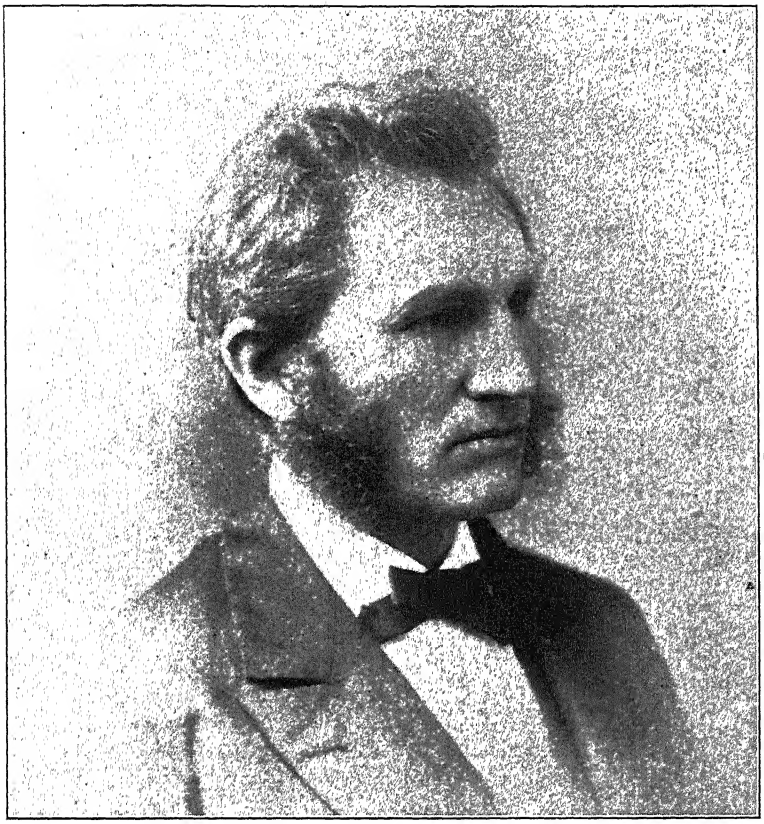
ALFRED RUSSEL WALLACE

A PHOTOGRAPH TAKEN IN 1878 WHEN HE WAS FIFTY-FIVE YEARS OLD.

tary organization of labour for the good of all.'' From that time forward he wrote trenchant criticisms of the functioning of capitalism, of which ''Social Environment and Moral Progress'' (London, 1913) is the most effective. Ward remained more academic in his advocacy of equality of opportunity for the masses of mankind; he preferred not to call himself a socialist but coined the term sociocracy to designate his ideal of eliminating inequalities and conferring social and economic benefits scientifically in strict proportion to merit within the framework of capitalism.

Wallace's persistent defense of spiritualism, which developed from his youthful interest in mesmerism, formed the basis also of his chief difference with Darwin over the application of theory of evolution to man, for Wallace insisted on a spiritualistic explanation of man's conscious activity. Ward, on the other hand, was outspoken in his agnosticism; in his youth he edited and wrote most of the copy for a magazine called the *Iconoclast*. He refused to curtail or modify his criticism of religion in ''Dynamic Sociology'' (2 vols., New York, 1883), although pressure was put upon him to do so by the publisher and by such sociologists as Albion W. Small.

In their scientific work Wallace and Ward were closely associated. In his discussion of the geological evidence of evolution in ''Darwinism'' (London,



LESTER F. WARD
A PHOTOGRAPH TAKEN IN 1886 WHEN HE WAS FORTY-FIVE YEARS OF AGE.

1889) Wallace used Ward's studies of the nervation of fossil leaves to show the progressive development of the vegetation of the earth.

New evidence of the friendly relationship between the two men and interesting sidelights on Wallace's views are found in the hitherto unpublished letters from Wallace to Ward discovered among the latter's manuscripts in the library of Brown University.[2]

Godalming, England, *September 25, 1887*

The receipt with other books &c. of your very fine & interesting "Flora of the Laramie Group" [U. S. Geological Survey, *Sixth Annual Report*—Washington 1887—pp. 399–557]—reminds me that I must write to you, not only to thank you for it, but also to let you know that I have reached home & to give you a short résumé of my tour after leaving Washington.

I staid a week at Cincinnati & saw there the spring flora pretty well developed in some of the bits of forest near the City; and also visited several of the Ohio mounds. At Sioux City, Iowa, I met Miss Bandusia Wakefield, a fine botanical artist & amateur botanist. At Lawrence, Kansas, I saw their (the University's) fine collection of Cretaceous Plants from the Sandstone nodules containing some very remarkable forms. At Manhattan, Kansas, Prof. Popenhoe took me on an excursion & showed me a good deal of the interesting Prairie flora which on some of the rocky hills was very rich and peculiar, and I saw more of it at Salina, Kan., where I staid a week. In California (end of May) I was too late for the beautiful spring

[2] Research by the editor on these manuscripts was made possible by a grant from the Social Science Research Council.

flowers, though at the Yosemite & "Bigbees" I saw some of the forest flora—the coniferous forests of the Sierra being grand beyond description; but on my return in July, I staid a week on the summit of Sierra Nevada & found the sub-alpine flora in perfection and very beautiful. I next staid a week in the Colorado Rockies, in the vicinity of Gray's Peak, which I ascended on foot, where I was enchanted with the glorious alpine vegetation above the timber-line, 11,000–14,000 feet. I sent home parcels of plants every day, and am glad to find that a large portion of them have arrived safe. Should you ever go to that neighborhood let me recommend you to go up a valley called "Grizzly Gulch" which is far more "flowery" than the usual trail to Gray's Peak. I left this spot with regret but I had to give a lecture at the Ag. College of Michigan, near Lansing in the end of July. There Professors Beal and Bailey kindly showed me the native vegetation in some tracts of virgin forest & bog, full of Saracenias & Habenaria ciliaris, & a great number of ferns, some of which I sent home. Finding the heat very great & the country too much dried up to be interesting to me, I spent a week with the *Allens* at Kingston, Can., & then sailed from Montreal the 10th August. During all my journeys I was very well in health except that I suffered from inflamed eyes which has become almost chronic so that I cannot work or read at night. If you have made your excursion to the Yellowstone, I suppose you will have returned by this time, and if you should have brought any *seeds* of showy flowers I sould be glad of a few. There are also a few Washington plants I should like. A fine pea—was it *Lathyrus venosus* or *Clitoria mariana* you said you could send me seeds of? I should also like some *roots* of *Viola pedata* var. *bicolor, Silene pennsylvanica, Orchis spectabilis,* & *Cypripedium acaule.* These will come well if the *roots* are tied up in damp moss, the *leaves* if any in *dry* moss, & the whole packed up in a roll in *oiled paper* or *tea-lead* with dry moss. The limit of weight is now 8¾ oz. so boxes are too heavy. Prof. Beal has sent me some plants in oiled paper which have come well:

Hoping you are quite well, and with kind remembrances to Mrs. Ward, and to all my Washington friends, Believe me,

Godalming, England, *December 24, 1887*

Thank you very much for sending me a copy of your valuable work on *Dynamic Sociology.* I have spoken of it to several friends here & have lent it to one of the masters of Charterhouse School, who is much pleased with many parts of it. Your excellent account of the Philosophy of *H. Spencer* & of *Comte* is greatly admired.

I am much pleased that Mrs. Ward should have read my "Inland Life" & been interested in it. I think she would find my "*Tropical Nature*" more generally interesting.

I should have much liked to have seen "High Island" in May & June but the fates forbade. Your spring is so dreadfully long coming! We have had no snow yet & very little frost, & my garden is full of young plants coming up ready for spring, *Narcissi, Snowdrops, Anemones, White lilies,* &c. while two or three species of *Helleborus,* which we call Christmas roses, are in flower. Thus the interest in our gardens never ceases, & every month in the year can afford some few out-of-door flowers. In this respect only California & Florida can equal us. Hoping to receive the promised seeds & plants next summer,

Parkstone, Dorset, *November 21, 1893*

Many thanks for sending me your new book—*The Psychic Factors of Civilization.* I have read the *third part* through, carefully, & think your exposition of the scientific character of *Socialism* as opposed to Herbert Spencer's *Individualism* exceedingly forcible, and calculated to do much good. I have also looked through & read a good deal of the *first* & *second* parts, which however being so purely psychological does not interest me so much. Chapter XVII on *Social Friction* is however an exception, & seems rather out of place, & would come better in the 3rd part. If these were embodied together, with a good deal more of concrete illustration, it would form an excellent work on the Scientific Basis of Socialism which would have great value as a weapon against the individualist school, and would enlighten many who are now blinded by the prestige of Spencer & the Political Economists. The greater part of your book is so purely *philosophical* and it is so difficult to see the bearing of several of the chapters on Social reform, that I fear it will not reach beyond students of philosophy & psychology, & thus have less influence than it deserves to have in shaping public opinion as to the true method of political and Social advance.

No doubt we *are* advancing on the very lines you point out as the true ones, but only empirically, and so much in the very teeth of the popular political economy that politicians only give way to it as a concession to the demands of the populace. I think I shall try to make known your doctrine in the form of a popular review article, though it will be a difficult job.

How dreadfully Herbert Spencer has fallen off in his *Justice.* Parts of it are so weak and

illogical as to be absolutely childish. You have no doubt seen H. George's severe criticism of it.

Parkstone, Dorset, *June 7, 1894*

I am glad to hear you are coming to England. I shall not be at Oxford myself as I have long given up attending the Association, but I shall hope to see you here, either before or afterwards, & shall be glad to give you a bed for a few days & accompany you to Weymouth & Portland. You will probably meet Carruthers of the Nat. Hist. Museum, who, if I mistake not, has also studied the Cycads, & no doubt they have a fine collection at South Kensington. I have no doubt Mr. Mensell-Pleydell—a good local botanist & geologist, author of the "Flora of Dorsetshire"—would accompany us to Portland & shew you the best localities for the plant-remains. At Portland there are fine specimens of trunks 20 feet long & more outside some of the houses, and I dare say there are some good private collections, & also at the Dorchester Museum.

We are here moving on rapidly towards Socialism, more so, I think, than you in America. The majority of our more intelligent workers are socialists, but of a reasonable type, who never even think of force, but of educating their fellow-workers & then carrying out their own ideas & principles by the majority they will some day have in Parliament.

Please let me know when to expect you. There are trains from Oxford here.

Parkstone, Dorset, England, *October 12, 1898*

I should have acknowledged your *Outlines of Sociology* long ago, but I was busy bringing out my own book, and with discussions & correspondence on the Vaccination question. I read most of the chapters of your book in the copies of the original papers which you were so good as to send me, but I am glad to have the connected whole, which contains I think some of the best things re Sociology you have written. Never was sound teaching on the subject more wanted, and wise legislation, if we are not to be soon plunged into a revolution. I have been reading with great interest Mr. Wyckoff's papers on the Workers in Scribners' Magazine, and I ask myself how much longer will men continue to work at their highest tension for a bare supply of necessaries and with no prospect of rest and comfort in old age? And even to get work at all, on these terms, becomes increasingly difficult. The whole miserable system—or want of system—has also been brought more vividly before me by my son's experience in America where he has now been a year and a half. He has had the best education I could give him in Electrical Engineering—3 years in College and 3 years in the workshops & at various jobs. So far, in America, he has been able to get nothing but labourer's or lineman's work at moderate wages, but the bosses always keep them at high pressure for nine hours a day, after which of course they are not fit for much but eating and sleeping. He enjoys the work greatly, being young and strong, especially as it has enabled him to see already a good deal of the country & people. He & a friend who went out with him worked their way, mainly bicycling, from Boston through the Adirondacks to Niagara, Chicago, and to Denver, and they want to go across to California if they can manage it. He is a thorough Socialist, and makes friends with most of the men he works with, but after a job, they often have weeks or months of idleness before they get another. What a terrible thing it is that under the present social system, the vast majority of workers, however steady and well educated, have, and can have, no prospect but a life of toil and an old age of poverty or worse—and this when the work actually done, if properly organized, would provide not only necessaries but comforts for all, with ample leisure and a restful old age. Surely the coming century must see the end of the existing system of cut-throat competition, and wealth-production based on the misery & starvation of the millions!

DAVID WHITE

THE PROGRESS OF SCIENCE

DAVID WHITE: AN APPRECIATION

In the death of Dr. David White at Washington, D. C., on February 7, in his 73d year, science in general and the science of geology in particular lost one of the most accomplished and distinguished of its representatives.

A graduate of Cornell with the class of 1886, thoroughly grounded in systematic botany, paleontology and general geology, he was appointed to the staff of the U. S. Geological Survey before graduation, at first to assist Professor Lester F. Ward, in charge of the survey's paleobotanic work, in preparing illustrations of plant fossils for publication.

White's field, however, soon broadened, and after a brief excursion into Cretaceous paleobotany, evidenced by a paper on some collections from Gay Head, Martha's Vineyard, he early began to specialize in the fossil plants of the Paleozoic, a field in which Leo Lesquereaux had done the preliminary work. Within a few years, White's studies of the paleobotany of the Appalachian trough led him to conclusions about the stratigraphic relations of the Pennsylvanian beds that were widely at variance with the then generally accepted views of such eminent authorities as John J. Stevenson and I. C. White. David White's conclusions, however, at first regarded as revolutionary, gradually won acceptance and were quietly adopted by the state geologists of West Virginia, Tennessee, Kentucky, Alabama and Georgia. Thus by the beginning of the century he had won recognition as the leading stratigraphic paleontologist in his field in the United States.

From this time forward White's fields of activity and his personal influence gradually extended. No geologist working on the difficult stratigraphy of the eastern coal fields was willing to announce conclusions unless they were verified by the evidence of the fossil plants as interpreted by White.

Always a thorough and critical field observer and a skilled microscopist, he managed, as a by-product of his paleobotanic work, to collect a large body of evidence on the constitution and evolution of coal. Thus he eventually became our leading authority in this field and meanwhile was laying the groundwork for his later great generalization on the limits of oil fields, known as the carbon-ratio hypothesis.

Much of Dr. White's work illustrates the truism recognized in scientific circles, but often doubted outside these circles, namely, that even the purest types of research, entered upon with no thought of their economic significance, may nevertheless prove to have very definite economic value.

The systematic study of fossil plants would scarcely be constructed as coming within the field of economic geology, yet the identification of coal beds from outcrop to outcrop, through the associated fossil plants, and the determination that favorable structures in apparently favorable rocks can not contain commercial petroleum because associated coals indicate that metamorphism has gone too far, have the greatest economic significance.

Important and diverse as were White's direct contributions to geology in the fields of paleobotany, stratigraphy, isostasy and origin and evolution of coal and oil, they were even surpassed by his indirect contributions. Always an enthusiastic and indefatigable student himself, he was a constant inspirer of others. He took the keenest delight in bringing together a promising student and a difficult problem, suggesting and counseling out of his own broad experience, helping to overcome difficulties and lending constant encouragement wholly

regardless of any drain upon his own energies. His generosity, enthusiasm and keen personal interest, backed by his encyclopedic knowledge and his example of indefatigability, were constant sources of inspiration to his associates. There was something eternally youthful about him, something that time could not affect. His view was always ahead, toward new problems awaiting solution and the men and means for their solution. His passion was to reduce constantly the unknown by adding to the known. His life was a continuous assault on the limits of our knowledge for the purpose of pushing them back. Thus he was an intellectual imperialist, engaged in constantly extending the domain of the human mind, as all real scientists must be. Nor did he ever stop growing. Many of us by middle life lay up a capital of knowledge and thereafter live upon its income, but David White's avidity for research was as keen at 70 as at 30.

Through administration also, White contributed much to geologic advance in this country. He was chief geologist of the Geological Survey from 1912–22, chairman of the Research Council for the next three years, home secretary of the National Academy of Sciences for four years and its vice-president for two years.

During the period of the world war he developed the activities of the geologic staff of the survey into those channels of greatest service in the emergency, and at all times then and later, his counsel was enlisted through board and committee services of great variety. While these activities interfered with his own personal studies, they expanded his influence in many directions and permitted his spirit and his ideals to permeate many of the fields of science.

He stands then as an investigator of the first rank. Early established as the authority on the plants of the Coal Measures he, by that accomplishment, attained as much as is within the power of most men within a lifetime. But in addition to this he has done more than any one else, on this continent at least, to reveal the complete story of the evolution of coal of all ranks and of oil. His carbon-ratio hypothesis is one of the great generalizations of the century. He touched with profit to geologic science upon the field of isostasy. He has dealt in an illuminating way with the earliest forms of life on the planet, the fossil algae of the pre-Cambrian.

In addition to his personal accomplishments he inspired and aided many along the pathway of life. Vivid, generous and self-forgetting, he was quite as keenly interested in the sound accomplishments of his younger associates as in his own. His work will go on through them.

It is gratifying to know that Dr. White received many evidences during the last dozen years of his life of the esteem in which his associates held him. Honors from universities and scientific societies here and abroad were bestowed upon him. From these no doubt he derived much quiet satisfaction, and his associates who are left have the comfort of knowing that he did not depart from us without knowing how we felt about him.

W. C. Mendehall,
Director
The U. S. Geological Survey

DR. ISAIAH BOWMAN, PRESIDENT OF THE JOHNS HOPKINS UNIVERSITY

In choosing Isaiah Bowman as its fifth president, the Johns Hopkins University turns again to the field of geography, from which its first president, Daniel Coit Gilman, was called. Between the two stand Ira Remsen (chemistry), Frank Johnson Goodnow (political science) and Joseph Sweetman Ames (physics). The delicate question of favoritism as between the sciences and the humanities is thus answered or avoided, for geography is a child of these two parents and honors them equally. The first and fifth presidents

DR. ISAIAH BOWMAN

have both been associated with Yale, where the former was professor of physical and political geography in the Sheffield Scientific School. Friends of Hopkins will hope for another parallel. The man who chose Gildersleeve and Sylvester and Martin and Rowland and Newcomb at the outset, when it was necessary to meet classes in old dwellings, knew something of men and was able to distinguish between the essentials and the incidentals of a university.

The new president's mature years have been given to teaching, to productive scholarship and exploration and to administration in almost equal measure. His teaching began in the public schools of Michigan, where he grew up. It continued in the State Normal School (now College) at Ypsilanti in association with Mark Jefferson. Again at Harvard, before his graduation in 1905, he was assistant in physiography under William Morris Davis. Those who knew Jefferson of Ypsilanti and Davis of Harvard might well expect that the future geographer should be exact in his own scholarship and properly rigorous in his requirements of others. Ten years were then spent as instructor and assistant professor at Yale. Formal teaching ended in 1915, when he became director of the American Geographical Society and editor of its publications.

The American Geographical Society was already a distinguished institution. Its library, map collection and *Bulletin* gave it rank among the leading geographic societies of the world. In 20 years these have been greatly developed. The character and the success of *The Geographical Review* (successor to the *Bulletin*) would of itself give distinction to any scientific society.

It was during his service at Yale that Bowman did his work as an explorer. He was leader of the first Yale South American Expedition in 1907 and geologist and geographer of the Yale Peruvian Expedition in 1911. His first intimate connection with the American Geographical Society was in 1913, when he headed the expedition of that body to the Central Andes. The maps and reports resulting from these expeditions greatly increased the world's knowledge of little-known regions and stimulated interest in our neighbor continent.

It required initiative, even daring, to lead the American Geographical Society into committing itself, its resources and its future prospects to a project which is, beyond comparison, the greatest single piece of work ever undertaken by a geographical society, that is, the compiling of a map of Latin America on a scale of 1:1,000,000 in conformity with the standards of the "Millionth Map of the World," sponsored by the International Geographical Congress. Work was begun fifteen years ago and is now far advanced. The total cost will be several hundred thousand dollars. A special staff was assembled for the purpose and many thousands of maps, traverses, surveys of claims and confidential documents have been subsidiary to the work. To say that Latin America is now better mapped than the United States would be ambiguous and in a sense incorrect. But to say that the *existing knowledge* of South America is vastly more available for general use than the corresponding knowledge of the United States is a safe statement.

Among the necessities of the war was that of getting ready for the peace conference. A body, undefined by law and known simply as "The Inquiry," functioned under the general supervision of Colonel House, by order of the President. After passing through several tentative forms it took final and effective form under the direction of a triumvirate consisting of Isaiah Bowman, Allyn Abbott Young, of Cornell University, and Charles Homer Haskins, of Harvard. The work of a large staff was carried on for many months at the house of the American Geographical Society, the immediate direction being largely in the hands of Dr. Bowman, who accord-

ingly became chief territorial specialist for the American Commission to Negotiate Peace and a member of various other territorial commissions during the sessions of the peace conference.

Each part of this active career has given occasion for one or more books. A lasting result of the ten years teaching at Yale was a massive volume called "Forest Physiography." It embodies the first systematic treatment of the physiography of the United States in the light of geologic and other scientific literature. Even now, after twenty-four years, it stands alone for half the area of our country. Two or three volumes followed the exploration in South America, and as many more the Peace Conference. Recent books on "The Pioneer Fringe" and "Geographical Thought in Relation to the Social Sciences" are essays in the treatment of human relations, toward which field the author has steadily advanced from his earlier studies in the physical basis of geography.

A call to the chairmanship of the National Research Council in 1933 resulted in an arrangement by which Dr. Bowman gives one half of each month to that position and the other half to his former work. The work in Washington has entailed other responsibilities, among them the vice-chairmanship of The Science Advisory Board, whose work, though but little publicized, deals with many basic governmental functions.

Honors, offices, medals and memberships in learned societies, home and foreign, have come to Dr. Bowman in abundance and are listed in published biographical sketches. Among the more recent honors was the presidency of the International Geographical Union, which met in Warsaw, Poland, in the summer of 1934.

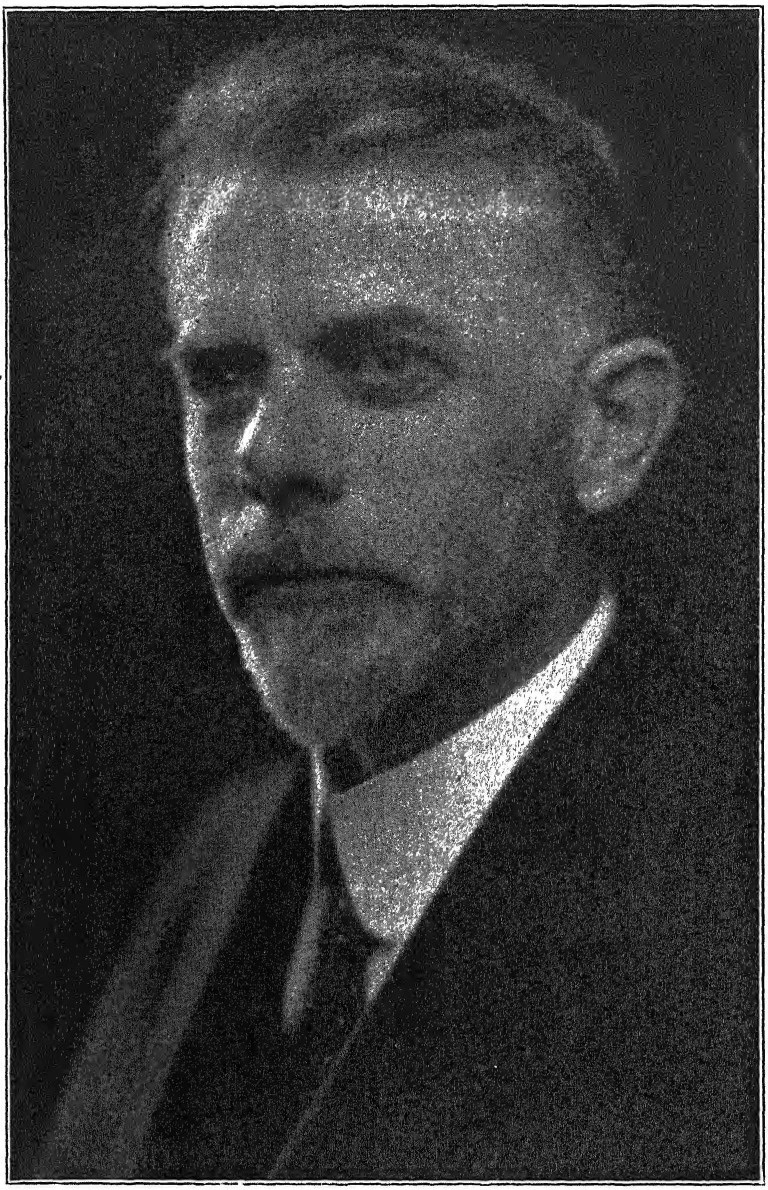
NEVIN M. FENNEMAN
Professor of Geology and Geography
UNIVERSITY OF CINCINNATI

PROFESSOR CHARLES A. KRAUS, WILLARD GIBBS MEDALIST

THE Chicago Section of the American Chemical Society has recently announced that Dr. Charles A. Kraus, professor of chemistry and director of chemical research at Brown University, has been selected as the recipient of the Willard Gibbs Medal for 1935, for outstanding work in the field of chemistry. This award was established in 1910 by William A. Converse, and each year, with the exception of 1922, has been made to a chemist for important and distinctive work in the advancement of the science. It is regarded as one of the highest honors that can be bestowed upon any chemist by American chemistry.

Dr. Kraus received the bachelor's degree in electrical engineering at the University of Kansas in 1898. While still an undergraduate he became interested in the properties of metals and liquid ammonia solutions. Interest in the latter was due to the influence of Dr. E. C. Franklin, at the time professor of chemistry at the University of Kansas. Several articles were published by these two workers before 1900 relative to the physical and chemical properties of liquid ammonia solutions.

Later Kraus found his way to the noted laboratory of A. A. Noyes at the Massachusetts Institute of Technology, and in 1908 he was awarded the Ph.D. degree for work on the properties of solutions of metals in liquid ammonia. He showed that the alkali metals are capable of forming solutions with ammonia, a non-metallic solvent, which at high concentrations behave as metals, in that they conduct electricity metallically, while at low concentrations they are salt-like or ionic in nature, in that they exhibit the electrolytic type of conductance. These studies and others of a similar nature carried out by Kraus have led to developments which are of importance in the understanding of the metallic state of matter. The actual ex-



PROFESSOR CHARLES A. KRAUS

perimental work was accompanied by many difficulties, but terminated successfully, due, for the most part, to the extraordinary manipulative skill and keen imagination of Kraus.

Many other problems involving liquid ammonia as the solvent medium have been investigated by Kraus. He has used this solvent because it offers better experimental conditions for the problems which have occupied his attention. Many of the substances he has studied are either not soluble in water or do not exist in an aqueous medium due to their extreme reactivity. For example, the alkali and alkaline earth metals, metallic compounds, such as Na_4Pb_9, Na_3Sb_7, Na_3Bi, Na_4Sn_9, etc., are not capable of

existence in water, but all are soluble in liquid ammonia with the formation of stable solutions.

The latter named substances, the metallic compounds, have received considerable attention by Kraus in his researches. He has demonstrated that the alkali metals react with many of the less electropositive elements, such as lead, tin, antimony, arsenic, bismuth, selenium, tellurium, etc., to form metallic compounds in ammonia, in which medium they behave as salts, are excellent conductors of electricity, undergo metathetic reactions with other substances, and exhibit properties characteristic of salts dissolved in water. Studies of these solutions have yielded many important results concerning the nature of metallic compounds.

Early in his career Kraus became interested in the properties of free groups. In this field he has studied the triphenyl methyl, alkyl-mercury, substituted ammonium, trimethyl tin, dimethyl tin, calcium hexammonate groups and several others. In connection with these groups many problems developed relative to the chemistry of organic compounds of metals, particularly of the third and fourth groups of the periodic table. Thus it is not surprising that, in the autumn of 1922, he was called upon to find a method for the preparation of lead tetraethyl which would be feasible on a large-scale production. After a few months' work he found success in the reaction which proceeds between NaPb and ethyl chloride at a relatively low temperature and pressure. The process used to-day in industry is essentially the same.

The chemistry of solutions of metals in liquid ammonia represents another phase of the field which has occupied Kraus' attention. He had predicted earlier that these solutions should serve as excellent reducing agents, since they give in ammonia the normal alkali metal ion and the ammonated electron, the latter being available to any group or atom which might have the slightest tendency to acquire it. The formation of metallic compounds represents one example of this type of reaction in ammonia. He continued these studies to include the reduction of many types of organic, metallo-organic and inorganic compounds, and some of the metallic and non-metallic elements.

Kraus has always been keenly interested in the electrical properties of solutions, particularly of non-aqueous solutions. He has carried out a great deal of work relative to the conductivity of substances dissolved in liquid ammonia, liquid bromine, acetone, isopropyl alcohol, dioxane, benzene and other solvents. In addition, he has investigated the conductivity of solid metallic compounds, alloys and glass. In 1922 he described the investigations of this field in the publication of an American Chemical Society Monograph entitled "The Properties of Electrically Conducting Systems." During the past few years his interest in this field has been directed chiefly to solvents of low dielectric constants and solutes consisting of large ions. This work is surely to be regarded as one of the most important contributions Kraus has made to our knowledge of electrolytic solutions.

Kraus left the Massachusetts Institute of Technology in 1914 to become director of chemical research at Clark University. After a stay of ten years here he moved to Brown University to occupy a similar position. To date he has contributed more than 100 articles in the fields mentioned above. In addition, he is credited with several patents dealing with the construction of graded glass seals, electrode seals, metal-glass seals, mercury vapor pumps and rectifiers. In 1923, he was awarded the Nichols Medal by the New York Section of the American Chemical Society for his work with nonaqueous solutions.

WARREN C. JOHNSON
DEPARTMENT OF CHEMISTRY,
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THE NEW MEDICAL BUILDINGS AT YALE UNIVERSITY

As the result of progress in a building program started fifteen years ago, the Yale University School of Medicine and the New Haven Hospital are now housed in a group of modern buildings uniform in architectural style and designed especially to facilitate the work of teaching, research and care of patients. In the group is included the Institute of Human Relations.

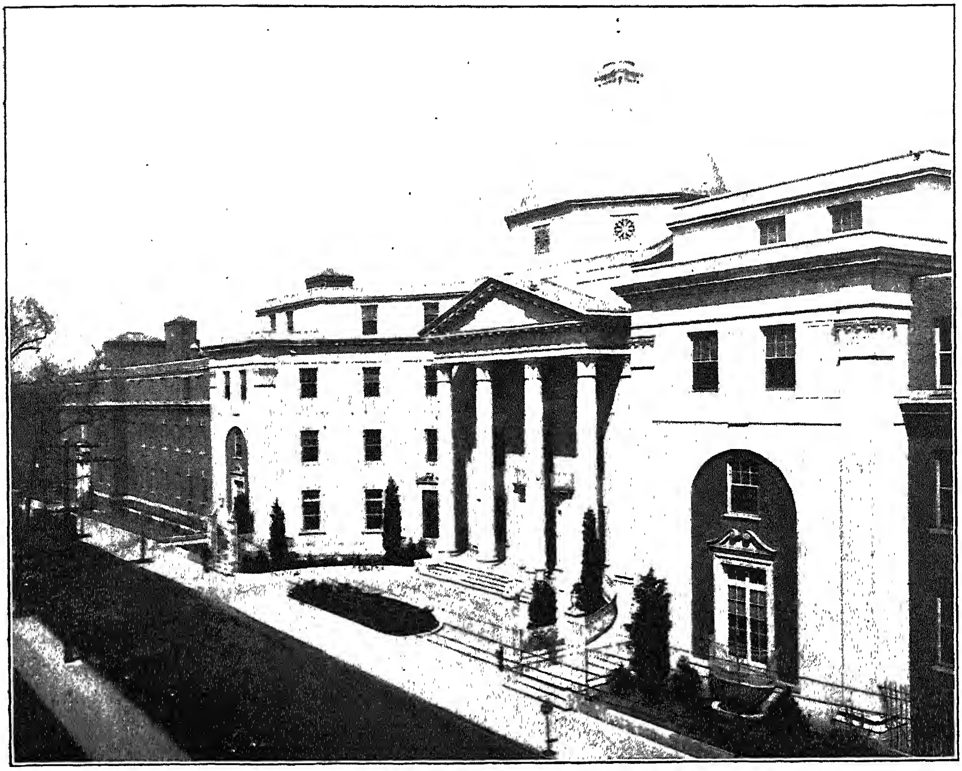
The buildings are of red brick with white stone trimmings, in a simple modified Georgian style. The first consideration has been to provide a maximum of space, air and light in well-coordinated teaching, research and clinical units. Ornamentation has been minimized, although the group as a whole is pleasing to the eye because of a unity attained by the arrangement of the massive structures.

There are approximately 14 million cubic feet of space in the group and the total cost of construction, with equipment, has been about $12,000,000, practically all of which has been provided specifically for the purpose by friends of the university. There are still a few old buildings to be replaced and new units to be provided, but the scheme as outlined some years ago has practically been realized. The group covers two city blocks, an area roughly one thousand feet square, divided by Cedar Street into two sections.

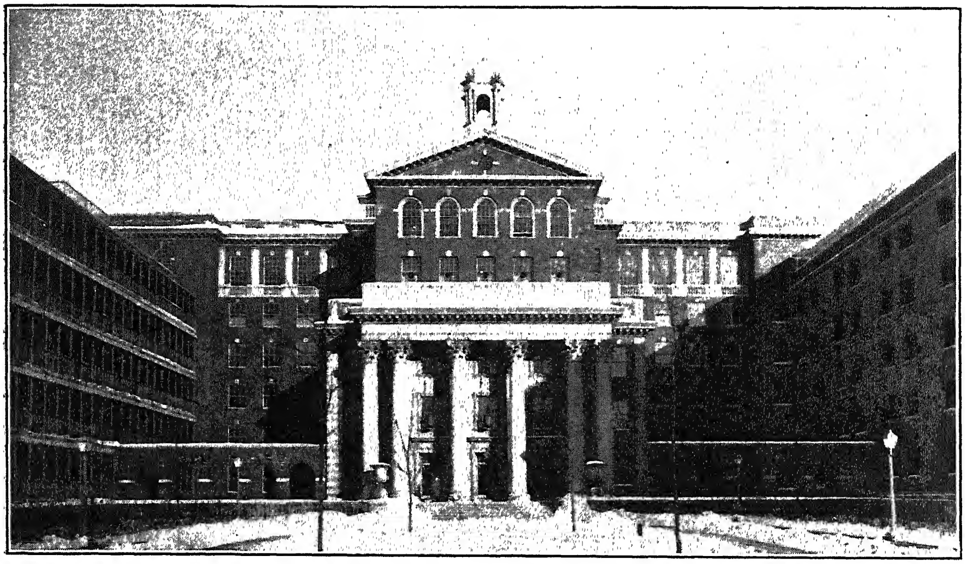
The units containing the preclinical science departments are located on the east side of Cedar Street. Laboratories of anatomy, physiology, physiological chemistry, pharmacology and psychobiology are contained in the Sterling Hall of Medicine. Articulated with this building is the Institute of Human Relations, containing clinical facilities of the department of psychiatry and mental hygiene, laboratories of psychology and physiological psychology, Clinic of Child Development and anthropology and social science research units. The Sterling Hall of Medicine also contains the library of the School of Medicine, amphitheater, administrative offices and recreational facilities, including lounge, gymnasium and squash courts. The institute building has a lounge and a dining room for staff members.

The buildings of the New Haven Hospital and of the clinical divisions of the School of Medicine are on the west side of Cedar Street, connected by underground passages with the Sterling Hall of Medicine and the institute. Heating and lighting are provided by a central power plant, and maintenance services of all buildings in the group are coordinated. The clinic building constitutes the center of the clinical division of the group. Patients for the hospital and dispensary all enter here and are directed by way of inside corridors and elevators to the various clinics and wards. The clinic building houses not only central administrative offices, including information, business and admitting services, pharmacy and x-ray units and social service, but also central kitchens, dining rooms and supply service.

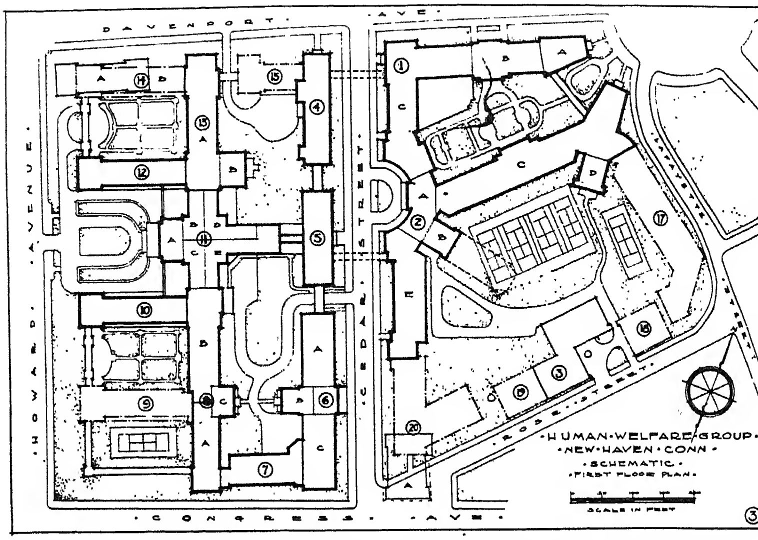
A transverse section, extending north and south from the clinic building, contains laboratories, offices, examining rooms, seminar and classrooms for the departments of medicine, pediatrics, surgery and obstetrics and gynecology. Pavilions for patients extend to the west at right angles with the laboratory units. Two new pavilions, the Raleigh Fitkin Memorial for medicine and pediatrics and the Sarah Wey Tompkins Memorial for surgery and obstetrics, are both six stories in height. Each of the five ward floors in each pavilion contain about twenty-six beds, ten of them in single rooms and the remainder in two-, four- and six-bed rooms. The ground floors contain the outpatient examining and treatment rooms. The Isolation Pavilion is an older structure, which will ultimately be replaced by a pavilion similar to the new ones.



ENTRANCE TO THE STERLING HALL OF MEDICINE AND THE INSTITUTE OF HUMAN RELATIONS



ENTRANCE TO THE CLINIC BUILDING OF THE NEW HAVEN HOSPITAL
SHOWING THE RALEIGH FITKIN MEMORIAL PAVILION ON THE LEFT AND THE SARAH WEY TOMPKINS PAVILION ON THE RIGHT.



A PLAN OF THE BUILDINGS IN THE HUMAN WELFARE GROUP

(1) INSTITUTE OF HUMAN RELATIONS. (2) STERLING HALL OF MEDICINE. (3) POWER HOUSE. (4) PRIVATE PATIENTS PAVILION. (5) BOARDMAN ADMINISTRATION BUILDING. (6) BRADY MEMORIAL LABORATORY BUILDING. (7) LAUDER HALL. (8) FARNAM MEMORIAL BUILDING. (9) FUTURE WARD UNIT "A." (10) SARAH WEY TOMPKINS MEMORIAL. (11) CLINIC AND SERVICE BUILDING. (12) RALEIGH FITKIN MEMORIAL. (13) MEDICAL AND PEDIATRIC LABORATORY. (14) A. EXISTING ISOLATION PAVILION. (1) B. FUTURE ISOLATION WARD "D." (15) FUTURE PRIVATE PAVILION ADDITION. (17), (18), (19), 20. FUTURE BUILDINGS. 20. A. EXISTING NEW HAVEN DISPENSARY.

Operating rooms are on the top floor of Farnam Memorial Building, the section housing the departments of surgery and obstetrics and gynecology. This section, like the section for medicine and pediatrics, has an amphitheater. The departments of bacteriology, pathology and public health occupy the Brady Laboratory and Lauder Hall, fronting on Cedar Street. The Boardman Memorial Building, containing offices and classrooms of the School of Nursing and the private pavilion, also front on Cedar Street. All construction is on the unit basis, with all units interconnecting and with a minimum amount of fixed equipment. This allows for easy contraction and expansion of all units to meet current needs, an economical arrangement, since it is impossible to predict departmental developments which will take place from time to time.

The scheme of the buildings is in accord with the general policy of the school to coordinate the activities of its many departments and to function educationally as a unit as far as possible. Wards, outpatient clinics, research laboratories, offices and amphitheaters associated with each service are adjoined vertically or horizontally, related services, such as surgery and obstetrics and gynecology on the one hand, and medicine and pediatrics on the other, are located next to each other, and general services for the use of many departments, such as x-ray, pharmacy, social service and admitting offices, are centrally located so that they will be nearly equidistant from all the sections which they serve.

Although the success of a School of Medicine, or any other human institution, is measured by the quality of its product and not by its buildings, Yale has acted on the theory that well-planned physical facilities constitute an important asset in medical teaching and research if they can be provided, as they have been at Yale, without detriment to teaching and research budgets.

H. H. L.

THE SCIENTIFIC MONTHLY

MAY, 1935

ADMIRAL PEARY, THE DISCOVERER OF THE NORTH POLE

By Professor WILLIAM HERBERT HOBBS
DIRECTOR OF THE GREENLAND EXPEDITIONS OF THE UNIVERSITY OF MICHIGAN

THE year 1934 marks the quarter-centennial of the discovery of the North Pole on April 6, 1909, by Robert Edwin Peary, after three centuries of the keenest international rivalry. This final conquest by the famous American explorer, after fate had intervened to frustrate his best endeavors throughout no less than twenty-three years of Arctic struggle, was regarded as so outstanding a milestone in the forward march of our nation and of the race that the President of the United States, the Honorable William Howard Taft, in his second annual message to the Congress, referred to the achievement in the following paragraph:

> The complete success of our country in Arctic Exploration should not remain unnoticed. . . . The unparalleled accomplishment of an American in reaching the North Pole, April 6, 1909, approved by the most expert scientists, has added to the distinction of our Navy, to which he belongs, and reflects credit upon his country. His unique success has received generous acknowledgment from scientific bodies and institutions of learning in Europe and America. I recommend fitting recognition by Congress of the great achievement of Robert Edwin Peary.

After a committee had made an exhaustive study of his narrative and observations, by concurrent action the two houses of Congress awarded Peary an official vote of thanks with a recommendation that he be elevated from the rank of commander to that of rear admiral in the United States Navy, and this appointment was made by the President.

The international significance of Peary's conquest of the Pole was indicated when every geographical society of note throughout Europe and America awarded him their most distinguished medal, decoration or other appropriate honor, such as had been done in the case of no other explorer in the history of the world. It was an outstanding example of recognition of merit which took no account of national boundaries.

Unfortunately, the return of the discoverer from the scene of his greatest achievement had been marked by the perpetration of the most stupendous public swindle in the history of science. This was the claim set up by a rival explorer that without any considerable preparation or adequate equipment he had arrived at the Pole and was the real discoverer, since he was there nearly a year earlier than Peary. As a result of this astounding assertion, which the general public was in no position to examine critically, this rival claimant throughout a period measured in months spoke before vast audiences throughout the United States and reaped a great harvest from the box office before his so-called observations were at long last submitted

ROBERT EDWIN PEARY
A PHOTOGRAPH TAKEN IN THE AUTHOR'S OFFICE AT ANN ARBOR IN 1915.

to a scientific council of his own choosing in Copenhagen. They were then found to be entirely worthless, and "Dr. Cook" thus became a byword for swindler throughout two continents.

The attainment of the Pole by Peary was achieved as the result of a matured plan which had been built upon earlier defeats and was executed with masterful generalship, but with hazards due to caprices of weather over which only the favor of fortune could prevail; and this for once was accorded him. As an exhibition of personal prowess in endurance of hardship and toil under adverse physical conditions, the successful polar expedition of 1909 in no way equalled his earlier northern conquests, such as the two double crossings of North Greenland in 1892 and 1895, or the circuit of the entire North Greenland coast in 1900.

For each of these three great achievements, which had astounded the world, so much did they surpass by their long marches all earlier dog-sled journeys, the irrefutable proofs that the goals claimed to have been reached were actually attained stand ready at hand. These proofs lie in the precious autographed records deposited by Peary within cairns—piles of stone in pyramidal form—which he had erected at significant points and at all places where he had turned back to his base. In every case without a single exception these precious records have been subsequently found in the places claimed, and either copied, photographed or brought back to civilization by some well-known explorer, who thus supplied the proof that he also had attained a goal of the great Peary.

In the case of the North Pole no such proof could possibly be supplied unless a later explorer were to follow close upon the heels of the earlier; for the North Pole lies in the midst of a frozen sea on the surface of which the ice floes are shifted about with each strong wind. As well might one deposit a record in a boat adrift in the open sea as upon the sea ice of the Arctic Ocean. One would be about as likely to be found as the other. The extreme probability, amounting almost to a certainty, that Peary reached the close proximity of the Pole lies in many important considerations, not the least of which was the high sense of honor of the man, recognized by all his contemporaries in exploration who were familiar with his record. Said Dr. W. S. Bruce, one of the great Antarctic explorers: "I feel sure if Peary says he was at the Pole, then *he was there.*"

Long before Peary had attained the Pole the great Arctic explorer, Fridtjof Nansen, remarked to Theodore Roosevelt, "Peary is your best man; in fact I think he is on the whole the best of the men now trying to reach the Pole, and there is a good chance that he will be the one to succeed." When in 1908 Peary departed on the *Roosevelt* for his last and successful attempt to reach the Pole, Theodore Roosevelt said as he grasped the great explorer's hand, "Peary, I believe in you and I believe in your success." It was Roosevelt who wrote the introduction to Peary's book, "The North Pole," which he concluded with these words:

> Commander Peary has made all dwellers in the civilized world his debtors; but, above all, we, his fellow Americans, are his debtors. He has performed one of the great feats of our time; he has won high honor for himself and for his country.

Again we have the supporting testimony of all the members of his expedition. Of the successful polar party were such well-known explorers as Bartlett, MacMillan and Borup, each in charge of a supporting party; and in the polar party itself the Negro Matt Henson and the four picked Eskimos—Ootah, Ooqueah, Egingwah and Seegloo. It

CAPTAIN R. A. BARTLETT
COMMANDER OF THE *Roosevelt*, WHO COMMANDED THE LAST SUPPORTING PARTY ON THE POLAR TRIP AND TURNED BACK AT LATITUDE 87° 47′.

would have been desirable to have had a white man of the polar party, and Peary would certainly have taken Bartlett had it been at all possible. It was, however, absolutely necessary that a navigator should lead the Eskimos of the last supporting party back to the base; for if a storm such as that which shifted Peary's party of the preceding expedition sixty miles eastward were to break out on the return, the party would almost to a certainty be lost. Moreover, Peary clearly considered the not remote possibility that he might himself never return, and he desired that the record to latitude 87° 47′ should not be lost.

The noteworthy increase in the daily marches after Bartlett's departure has been often commented upon, and by hostile critics has been exaggerated so as to discredit Peary's narrative. To all such criticism, the facts give a complete and satisfactory answer.

First of all, the fundamental plan called for just such a dash from the most advanced base and Peary and the men, who from the start seemed likely to form the polar party on the basis of their superior qualities, had throughout been spared much of the gruelling work of the earlier stages so as to keep in condition. In the second place the condition of the sea ice improves steadily as the distance from the land increases, and after passing latitude 84° or 85° N. on Peary's course it takes on the less hummocky character of the ice east of Greenland, and is in fact spoken of as *Atlantic* ice, whereas the old hummocky ice south of that latitude is known as *paleocrystic* ice. For the last six days before the departure of Bartlett, the double group of sledge parties made average daily marches of about nineteen miles.

Quite as important as the change in the ice-surface was the change in the morale of both Eskimos and dogs once their faces were turned toward home, as is known to all who have experience with these people. Eskimos are very fearful of venturing far out on either sea ice or inland ice, and Bartlett, who pioneered throughout, has related how he would wait for the Eskimos to come up and sometimes go back and find them sitting idly on the sledges—"soldiering." They felt safe if they were near *Pearyarksuah* (the Great Peary), whom they almost worshipped and whom they trusted beyond all precedent.

It is a mistake to assume, as many have done, that the men walked. Wherever the trail was good, and from the Pole it was clearly marked throughout, the men generally rode upon the sledges while the dogs for much of the time raced for home throughout long marches when the greatest difficulty was to keep from falling asleep and dropping out on the trail. Where no trail is in sight dogs are driven with the whip, but over a marked trail, and especially one they know, they need no encouragement if in good condition. No attention was paid to day or night hours, as it was always light enough for travel, but the already built igloos along the trail were used for sleeping whenever necessary. There had been unexpected delays going poleward,

and Peary was fearful that, because of the lateness of the season and the arrival of the spring tides, the *big lead* would be found wide open to bar the return passage. This fear was upon the Eskimos, and when after the "big lead" had been crossed and the firm ice of the glacial fringe reached, they went fairly mad with delight now that the strain was over. Dancing and shouting, Ootah cried as he collapsed upon his sledge, "The devil is asleep or having trouble with his wife or we should never have come back so easily." Arrived at Cape Columbia, whence the expedition had started out over the sea ice, the party slept for two days to make up for that which had been lost on the homeward journey.

It should not be lost sight of that Peary was the most expert dog sledger of his day. When after the long sled journeys across and around Greenland nearly a score of years earlier, he had received from the Royal Geographical Society in London the coveted Patron's Gold Medal, the president, Sir Clements Markham, had said:

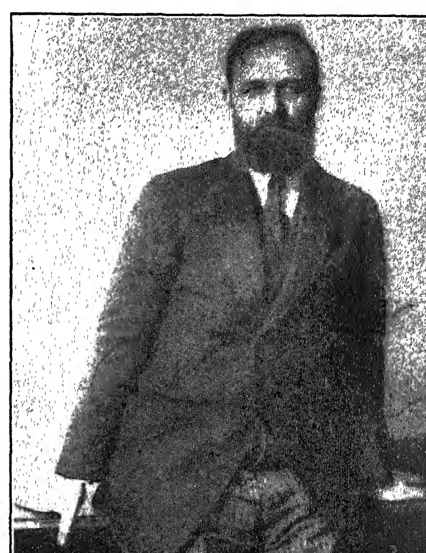
> Lieut. Peary stands quite apart. . . . His journey with the dogs over 1200 miles on the inland ice of Greenland is unequalled. . . .

The dash to the Pole and back from latitude 88° was made with the pick of the dogs and drivers of the entire Eskimo tribe, and Henson after eighteen years of experience was the equal of any Eskimo. Yet the average marches of the party over sea ice have been many times surpassed, not only by Peary but by many others. As one writer without knowledge of the matter has claimed in a sensational article that such speeds could not possibly be made, it may be well to institute some comparisons.

The average march of Peary northward to the point of Bartlett's departure reckons out as 12.8 miles, a figure which offers little basis for comparison with the average to the Pole after Bartlett's departure—26 miles—or with the average for the return—25.6 miles—for the reasons already given, and because the loads to latitude 88° were heavy, the trail was rough and had to be pioneered and improved, snow huts had to be built, and the large and relatively unwieldy party was then only slowly being "shaken down."

That the average marches during the dash to the Pole and back, outstanding as they were, were not without parallels in both earlier and later work should be clear from the following examples.

Before setting out on the Pole expedition Captain Bartlett had sledged with heavy loads from Cape Sheridan to Cape Columbia, a distance of 90 miles, in five marches, an average of 18 miles. The return journey with the dogs homeward bound and drawing light sledges, was made in one march of 90 miles. On the return from the Pole after two days' sleep at Cape Columbia, Peary made the



CAPTAIN PETER FREUCHEN
WHO BROUGHT PEARY'S RECORD AWAY FROM NAVY CLIFF. HE IS THE ONLY WHITE MAN WHO HAS BEEN THERE SINCE PEARY'S EXPEDITIONS OF 1892 AND 1895.

EXPLORERS AND GEOGRAPHERS AT THE COLOSSEUM IN ROME

WITH PEARY AND HIS FAMILY IN THE FRONT CENTER. THIS PHOTOGRAPH WAS TAKEN ON THE OCCASION OF THE MEETING OF THE TENTH INTERNATIONAL CONGRESS OF GEOGRAPHERS IN 1913. TO LEFT OF PEARY IN FRONT CENTER MARQUIS CAPELLI WITH ROBERT PEARY, JR., MRS. PEARY AND THE POLAR EXPLORERS BRUCE, STEFANSSON AND CAGNI.

same distance in two marches of 45 miles each. MacMillan and Borup on the return from Cape Morris Jesup to the *Roosevelt,* a distance of from 250 to 300 miles as traveled, covered the distance in eight marches, an average of 31 to 34 miles; though, instead of eight, the outward journey had required eighteen marches. Matt Henson, traveling the full twenty-four hours, once covered 100 miles in a single march.

Much more remarkable, however, in February, 1899, before the sun returned, Peary with both his feet frozen only six weeks before and the stumps of his amputated toes scarcely healed, sledged from Fort Conger to Cape D'Urville, a distance of over 200 miles, in eleven marches, an average of 20 miles, and in an average temperature of 53.5 degrees below zero. In March of 1902 he went from Cape Sabine to Fort Conger, a distance of from 250 to 300 miles as traveled, in twelve marches, an average of 21 to 25 miles; and he later covered the same distance again in 11 marches, an average of 22 to 27 miles. Belknap and Schmeling, of the Fifth University of Michigan Greenland Expedition, with only one season's experience in dog sledging, made an average march of 65 miles for four successive days, and on one day made no less than 80 miles. These are all nautical miles and over sea ice.

Gunnar Isaachsen says of the sledging on sea ice to the west of Grant Land, "We often made 20 to 30 miles and marches over 30 were not rare. Several times we made marches of over 70

miles.'' The wide variations are of course explained by the quality of the dogs, the ice conditions and the weight of the loads on the sledges. Peary left Bartlett for the Pole with moderate loads only, and on the return these loads were constantly diminishing.

Peary took infinite pains to furnish the proofs for his claim. On the route to the Pole a series of soundings was taken and one of these was within five miles of the Pole itself, where some thin ice suitable for cutting was fortunately found. Soundings, however, at best furnish a partial proof only if the sea bottom should later be found to be notably irregular. The only hope that they will be repeated lies in the Wilkins submarine expedition, for no explorer is likely again to repeat the hazardous journey across the sea ice.

Fortunately, however, the observations of the sun's altitude made by Peary at the Pole have as the result of a then unknown variation in the daily change rate of his standard chronometer supplied a convincing proof, as was pointed out by the distinguished computer of astronomical observations, Hugh C. Mitchell, to whom the polar observations of Peary after his return were submitted by the Committee of the National Geographic Society. The nature of this proof will therefore be stated.

Latitude is elsewhere obtained directly from the angular elevation of the sun measured against the horizon, either with a sextant or with a theodolite or a transit. Near the Pole the sun, when above the horizon, is at so low an angle that the horizon can not be seen, and an ''artificial horizon'' must be substituted —a level reflecting surface, such as a bath of mercury. It is necessary to take the sun's angle at intervals throughout the twenty-four hours; and if this is done at the Pole itself, the angles should agree throughout. From the variations of such readings the distance from the Pole may be determined.

Peary's observations, submitted to the committee of the Congress, were turned over to Hugh C. Mitchell and C. R. Duvall, the distinguished expert computers of astronomical observations of the U. S. Coast and Geodetic Survey. These technical experts, working independently of each other and employing different methods, obtained results which agreed within a second of angle for latitude. These give for the latitude of Peary's camp near the Pole, 89° 55′ 23″, and for the longitude 137° W. Hence the position of his camp (Camp Jesup) was 4.6 geographic miles distant from the Pole. But this was not Peary's closest approach to the Pole, for on the morning of April 7 at 6:40 o'clock, Peary traveled in the direction of the sun, immediately after taking his observations, for a distance of 8 miles, and so, as computed by the experts, he passed within a distance of 1.6 miles of the Pole. Further, Peary made trips of a few miles each in several different directions and it may be came within a stone's throw of the exact position of the Pole; but the point is one which has only an academic interest.

In his report Mitchell stated that from his professional experience he believed it would have been impossible for the data of these observations to have been obtained other than under the circumstances claimed. In using these observations in connection with each other, they in a measure prove each other; and error could be detected had the observations not been made at the points set forth in the data. The nature of this proof is not difficult to understand.

On the return from the Pole Peary's standard chronometer was sent to its makers for rating and comparison. When examined before the expedition

PEARY AND HIS FAMILY

AN ENLARGEMENT FROM THE PREVIOUS PHOTOGRAPH SHOWING FROM LEFT TO RIGHT, IN THE FRONT ROW: MARQUIS CAPELLI, PRESIDENT OF THE CONGRESS, WITH YOUNG ROBERT PEARY IN FRONT OF HIM; PEARY, MARIE PEARY STAFFORD (THE "SNOW BABY"), MRS. HOBBS, HOBBS, WOIKOFF AND WAGNER, DISTINGUISHED RUSSIAN AND GERMAN GEOGRAPHERS.

started the previous year, the makers had found it to have a *predicted* daily rate of two tenths of a second *losing*. On the return, however, the check-up showed that it had really had a daily rate of two and two tenths of a second *gaining*. Peary had taken at the Pole in all thirteen single, or six and one half double altitudes of the sun, at two different stations, in three different directions and at four different times. All except the first single altitude, taken on April 6, were under satisfactory conditions, and all at temperatures of $-11°$ F. to $-30°$ F., or above the freezing temperature of the mercury in the artificial horizon. At the time the observations were taken Peary *supposed* that his chronometer had been losing two tenths of a second daily, and as a consequence of the *actual* rate of 2.2 seconds gaining, he observed the sun for noon observation ten minutes before it was on the meridian. Mr. Mitchell states that the observations all show that the sun was actually where it must have been, not at the instants Peary at the time supposed, but at those which the behavior of the chronometer as later revealed indicated.

Some of the medals awarded Peary for his achievement of the Pole were: the Nachtigal gold medal of the Imperial German Geographical Society of Berlin, the Hauer gold medal of the Imperial Austrian Geographical Society of Vienna, the King Humbert gold medal of the Royal Italian Geographical Society of Rome, the gold medal of the Hungarian Geographical Society of Budapest, the award of the Royal Bel-

gian Geographical Society of Brussels, the gold medal of the Royal Geographical Society of Antwerp, a special silver trophy in the form of a ship from the Royal Scottish Geographical Society of Edinburgh, the Grand Cross of the Legion of Honor of France in Paris, both the Daly and the Cullum gold medals of the American Geographical Society of New York, the Hubbard gold medal of the National Geographic Society of Washington, the Kane gold medal of the Geographical Society of Philadelphia, the Culver gold medal of the Chicago Geographical Society, the gold medal of the Explorers' Club in New York and the medals from many municipal societies. The Royal Geographical Society of London at the time the Pole was reached had already awarded Peary for earlier expeditions the Patron's Gold Medal, and it was therefore decided to award him a great Special Gold Medal no less than three inches in diameter. Special gold medals had before been awarded but three times: a three-inch medal to Stanley in 1890 for the rescue of Emin Pasha and for the crossing of Africa, a two-and-a-half-inch medal to Nansen in 1897 for his great Arctic Expedition in the *Fram*, and a three-inch medal to Shackleton for his Antarctic Expeditions.

Other honors came to Peary in the election to the presidency of the American Geographical Society in 1903, to the presidency of the Eighth International Geographical Congress held in Washington in 1904, honorary vice-president of the Ninth International Geographical Congress held in Geneva in 1908, and of the tenth held in Rome in 1913. The honorary degree of doctor of laws was conferred upon Peary by the University of Edinburgh.

When the Great War broke out in Europe in 1914, Peary became actively interested in the defense of the country, and having early seen the importance of aircraft, he strove to secure for the Atlantic Coast a patrol by seaplanes. Always intensely patriotic, he threw himself heart and soul into the defense movement long before the President came to realize that America would be forced to abandon her position of neutrality and enter the war, and in this campaign Peary addressed large audiences on national defense.

The war ended, Peary soon became a victim of pernicious anemia before the now well-known means of combatting this dread disease had been discovered. For two years he fought its encroachments, in later stages with transfusions of blood, but in vain. He passed from life on February 20, 1920, at his home in Washington, and his body was lowered into the grave in Arlington Cemetery with full military honors. At the dedication of his monument there the President of the United States, the Chief Justice of the Supreme Court and those distinguished in many walks of life were present.

One of the greatest of all explorers, Peary was a great leader and a man of the highest sense of honor. By those who served under him he was almost worshipped, and he was loved and admired by those of a wider circle who were privileged to know him.

SOUND IN OCEAN SURVEYS

By Captain N. H. HECK

CHIEF OF THE DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY, U. S. COAST AND GEODETIC SURVEY

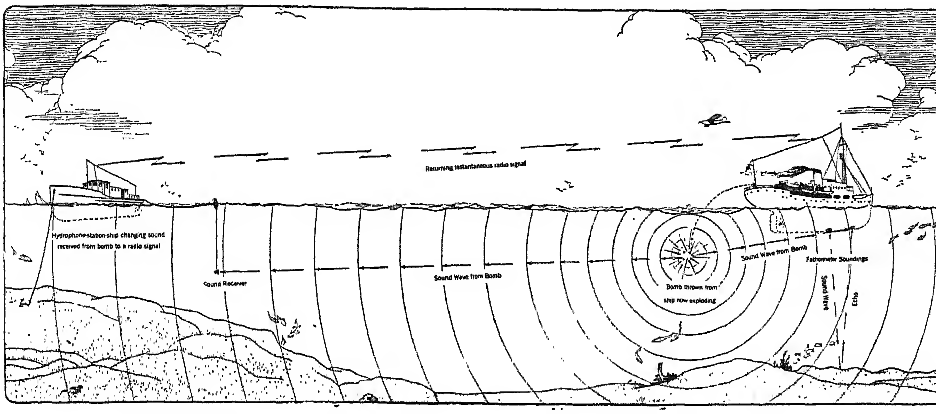
If the Coast and Geodetic Survey were to change its official emblem to a flower, it could well be the narcissus. You may recall Narcissus as the youth who pursued that elusive nymph Echo, who had pined away until nothing remained but a voice which always repeated the last words uttered in the vicinity. Narcissus in turn mistook his own image in the pool for the lost Echo, and he also pined away and was changed into the flower which bears his name. This ancient Greek myth of Narcissus pursuing the echo, or of the reflection of sound and light, is appropriate, since either the echo or the one-way path of sound has become the basis of modern hydrographic surveying; and there is always the hope that the velocity of light can be used for the measurement of distances on earth as in the heavens.

The use of the velocity of sound to measure distances is not so old as the myth, but it is by no means new. The method is mentioned by Jules Verne in his "A Journey to the Center of the Earth," with an amusing error. The adventurers had followed different underground passageways and had become widely separated; then they arrived at positions where they heard each other's voices through the rock. One shouted, noting the time on his watch; the other on hearing the sound immediately replied, and the arrival of the sound was noted by the first observer, thus obtaining the time interval. The error made by the author was in assuming that the velocity of the sound is 1,120 feet per second through rock. Actually the distance would have been nearly 20 times as great as they supposed.

Early works on hydrographic surveying give the method of base measurement by sound through air. A gun was fired, and the observer, perhaps three miles away, carefully noted the interval of time between seeing the smoke and the arrival of the sound. Fairly good results were claimed if there were three or four repetitions, although there are various sources of error.

The first use of the velocity of sound in sea water as a means of measuring distance is credited to R. A. Fessenden, who accompanied a Coast Guard vessel on the International Ice Patrol to the Grand Banks in 1913 in an effort to determine whether icebergs could be located by acoustic methods. It is nowhere stated that he was successful, but he did succeed in obtaining echoes from the bottom and conceived the idea of depth determination by this method.

The world war stimulated the development of many acoustical devices, particularly the transmission, reception and the recording of underwater sound signals. Apparatus for acoustic or echo sounding was devised and has been steadily improved. Much of the improvement has come from the rigid demands of accuracy by the Coast and Geodetic Survey, and this has culminated in the Dorsey Fathometer, which measures accurately depths as small as a few feet. This is named for Dr. Herbert Grove Dorsey, who has been in immediate charge of the acoustical development work of the Coast and Geodetic Survey since 1926.



FATHOMETER SOUNDINGS AND RADIO ACOUSTIC RANGING

Showing two of the scientific methods employed by the Coast and Geodetic Survey of the Department of Commerce to insure on nautical charts (1) correct water depths and (2) the precise positions of such depths, many of which are given for water areas far out of sight of land. Depths are determined with a fathometer, which measures the time required for a sound to travel to the sea bottom and return to the ship as an echo. They are made at the rate of 4 per second, while the survey ship proceeds back and forth over the area at her regular speed. The positions of these depths are fixed by radio acoustic ranging, from two previously determined positions, such as two station ships (of which one is shown). The time elapsed between the sound from the bomb as received on the survey vessel, and the radio wave from the station ships, is measured on the surveying ship to one one-hundredth of a second. Knowing the velocity of sound in water, the distance between the survey ship and each of the two station ships can be calculated accurately, even when separated by as much as 100 miles.

The demands of surveying have resulted in better instruments for acoustic sounding in navigation than would have otherwise been likely. The use of the method in navigation has changed the demands on the charts, for although some accurate soundings out of sight of land have always been required, the new method requires much more complete detail of the submarine configuration. Now, vessels frequently obtain their positions by recording a line of soundings over some characteristic detail of the ocean bottom and comparing these soundings with the chart. This method of navigation has emphasized another problem of equal importance to the actual sounding—obtaining an accurate position of the surveying vessel when objects on shore are invisible, due to distance or night or fog. A survey of the continental shelf of the Atlantic Coast of the United States had been started by precise dead reckoning just prior to the development of acoustic methods. This, while better than previous methods for obtaining the position of the surveying vessel, still left much to be desired in accuracy. Similar surveys on the Pacific Coast were complicated by the heavy fogs and strong currents, and work of acceptable accuracy was limited to areas within sight of land and in clear weather. Under any other conditions, the slow-moving surveying vessels which had to stop frequently for wire soundings were at the mercy of the vagaries of wind and current, and in consequence little reliance could be placed on their position.

The radio compass suggested a possi-

ble solution, but while very useful in navigation, it was found not to have the accuracy required in surveying.

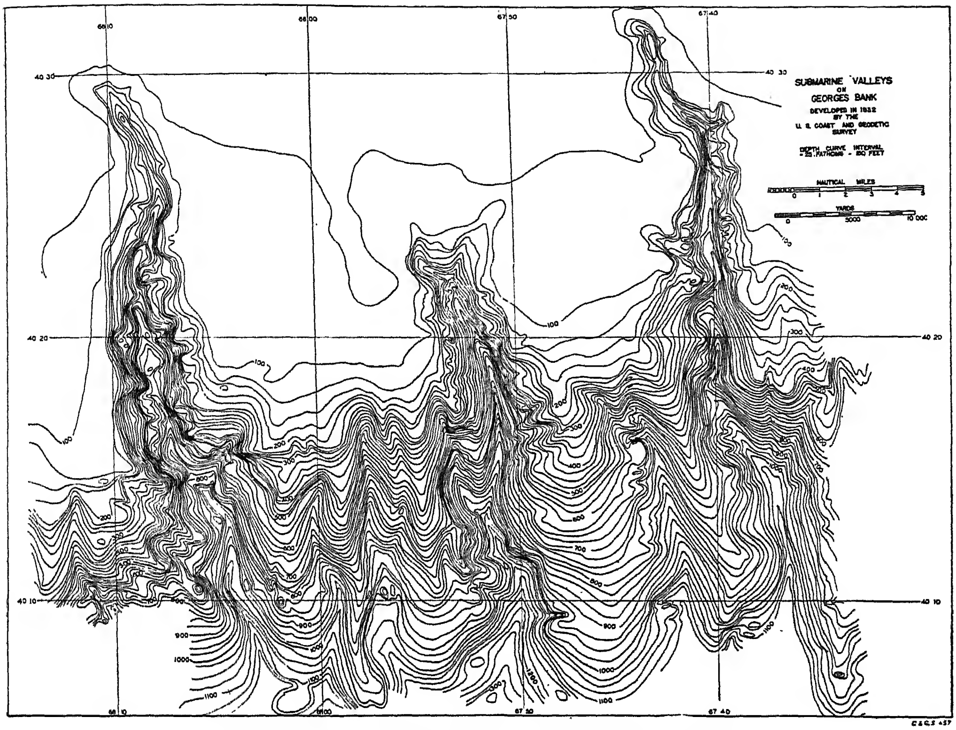
To meet these conditions, radio acoustic ranging was developed in 1923 by the Coast and Geodetic Survey, the apparatus being constructed and tested by the National Bureau of Standards. Previous work had been done by the British, but in no case had the feature which is largely responsible for the effectiveness of the method—recording aboard the surveying vessel—been adopted. After some tests at New London, Connecticut, in which officers of the Coast Artillery, U. S. Army, gave aid and advice, the work was transferred to San Diego, California. The writer, who had become familiar with this general type of work through naval anti-submarine duty during the world war, was associated with the development of radio acoustic ranging during its first year. The method was put into actual use during 1924. During the first years of development, there were several failures and some of the results had to be rejected, but by 1927 the new method had revolutionized all previous ideas of possible quantity and quality of results.

While the practical difficulties that caused this delay were great, the fundamental idea is simple. A bomb is fired near the surveying vessel, which is proceeding at full speed. A recorder somewhat resembling a stock ticker records on its tape the instant the impulse from the explosion reaches the ship's hydrophones, which are part of the acoustic sounding apparatus. In the meantime, the sound wave travels through the water until it reaches an underwater hydrophone connected by a cable to a shore station, where the arriving impulse is amplified and operates a thyratron, sending back a radio signal to be recorded on the same tape. The time interval thus is obtained to within one one-hundredth of a second, and this time interval with the velocity of sound along the path followed by the sound wave gives the ship's distance from the hydrophone. With two such distances to suitably placed hydrophones, the intersection gives the ship's position.

Assuming that we have the time interval to the required accuracy, there are two other important considerations—the velocity of sound and the path of the wave. If the sound wave traveled at a uniform velocity in a straight line, the problem would be quite simple. It appears from recent investigation that it probably travels by a series of reflections between the surface and bottom of the ocean, except in very deep water where it does not reach the bottom. Since the elastic and inertia constants of the sea vary with temperature and density, the velocity undergoes seasonal variations.

The theoretical velocities must be verified on the working grounds by comparison with some distance which is directly measured, *e.g.*, by taking visual fixes on shore objects that have been determined by triangulation, or by comparing the fathometer soundings with a direct measurement to the bottom with a steel wire. Many additional checks are applied daily to insure that the soundings and the features of the chart are correct in all detail.

Early studies of the velocity of sound include those of Colladon and Sturm in 1827. In this case the sound source was a submarine bell. More careful measurements were made by Threlfall and Adair in Australia in 1899, using explosives and electrical instruments and there have been various isolated measurements. The cruise of the Coast and Geodetic Survey ship *Guide* in 1923–24 from New London, Connecticut, to San Diego, California, via Puerto Rico and the Panama Canal, during which a very wide range of depth was encountered up to the greatest found in the Atlantic



SUBMARINE VALLEYS ON GEORGES BANK

These valleys are being studied by oceanographers and geologists in connection with the origin of the continental shelves and other interesting geological problems.

Ocean, resulted in the first accurate comprehensive velocity tables. These were compiled by Heck and Service immediately following the cruise. A little later, the British Admiralty published another set of tables, which differ slightly from those of Heck and Service.

One great advantage of this system of position determination is that the vessel is able, without effect on accuracy of subsequent work, to stop at regular intervals for wire soundings, to determine temperatures, secure water samples for determination of salinity and to obtain samples of the bottom. This information is in part needed for selecting the correct velocity of sound, but it is also useful to the physical oceanographer and the geologist.

When this method was first applied on the Atlantic Coast, it was found that shore stations could not be used. In order that the cables might not be of excessive length, the hydrophones have to be placed in very shoal water, and probably on account of loss of energy with multiple reflections, the sound does not go through. The use of two station ships solved this problem.

One important result was the survey of Georges Bank, which extends to 150 miles eastward of Cape Cod. In order to locate the station ships it was necessary to carry out a new kind of triangulation. Buoys were placed on the bank in such positions as to form a series of triangles or rather quadrilaterals which eventually formed a triangulation net over the entire area. The first buoys near the eastern extremity of the bank were located by precise astronomical observations, and these were connected

through to buoys in sight of the shore by measuring the sides and diagonals of the quadrilaterals by radio acoustic ranging. When the connection was made with the federal triangulation net on the shores, the error carried through this novel triangulation scheme proved to be surprisingly small.

During the past year by a combination of radio acoustic ranging and the British taut wire apparatus, even greater accuracy has been obtained. The taut wire apparatus consists of a large reel of steel piano wire mounted on the surveying vessel with registering sheave and suitable control, so that the wire can be readily payed out as the vessel steams along. To measure a distance as between two buoys, the end of the wire is anchored near one of the buoys and when the other buoy is reached, the sheave reading gives the distance with all required accuracy if the bottom is reasonably uniform. The combination of the two methods has resulted in even greater efficiency and reduced cost.

The purpose of these developments has been to produce charts which meet the needs of the mariner and add to the safety of life at sea, but there are important economic and scientific by-products. Fishing and the conservation and replacement of fish require accurate knowledge of the bottom. The Georges Bank charts have proved invaluable in this connection. The oceanographer needs accurate charts for many kinds of studies of the ocean, including the characteristics and circulation of the water. In geology, not only does the physiographer have a better understanding of what happens to the sediments which constantly leave the land, but the working area of the geologist has been extended to the edge of the continental shelf with accuracy comparable to that obtained on land. The finding of great gorges or submarine valleys has stimulated thought in regard to their possible origin. Accordingly work that was done to meet the needs of the mariner is aiding in revealing the history of the portion of the continent that is at present submerged beneath the sea.

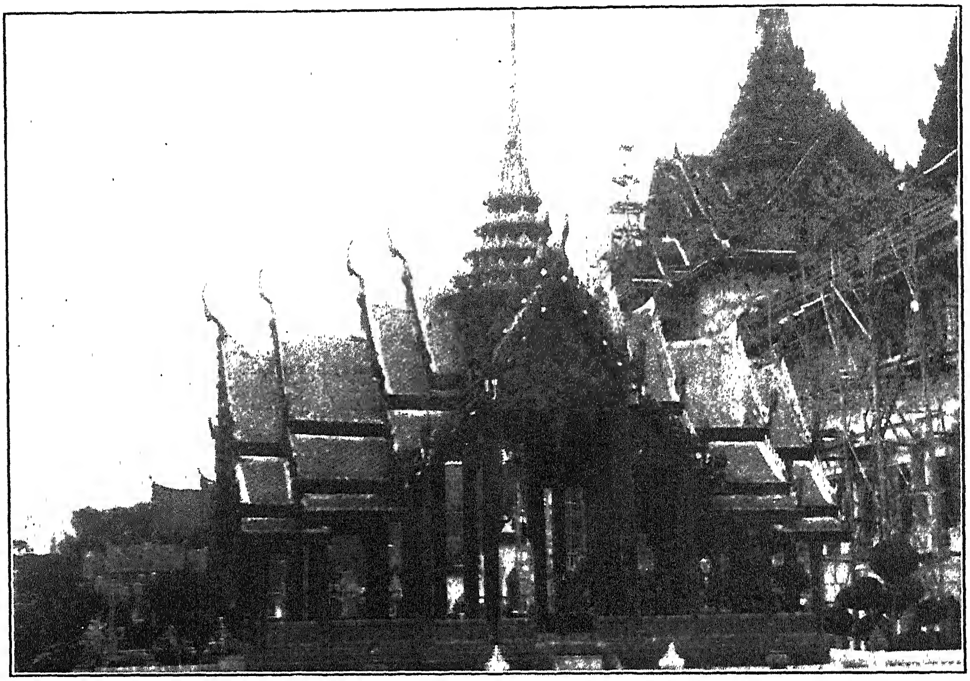
SIAM IN MAY

By Dr. A. S. PEARSE
PROFESSOR OF ZOOLOGY, DUKE UNIVERSITY

One goes by rail from Penang to Bangkok through a very picturesque country. Verdant buttes rise on either side of the railway. These have been beautifully eroded by nature, so that they are cleft and cavernous. Clumps of graceful toddy palms sway at the edges of fallow rice fields. These furnish wine and sugar for the Siamese. There are piles of cord wood at each station, for no coal is to be had and the fireman must work continually to keep up steam. Sitting in neat and well-appointed sleeping cars, a passenger roars through thatched villages. Now and then an elephant may be seen at his daily work. The gilded spires of Buddhist temples rise through the trees. Lotus blossoms make little wayside ponds charming.

Bangkok is perhaps the most fantastic city in the world. It is built along the banks of the Menam Chao Phya and its numerous klongs (canals) still serve as highways for most of its population, though modern roads also connect all parts of the city and are used by pedestrians, carts, rickishas and automobiles. Along the Menam for many miles there are pile-supported houses which can be reached only by water. Stores, post offices and residences bob up and down on flatboats. Little children and old women paddle about in boats that are no longer than themselves. The natives appreciate the "great mother of waters." They may be seen using her continually for transportation, bath, beverage, power and source of food. Rice boats ply back and forth. Great

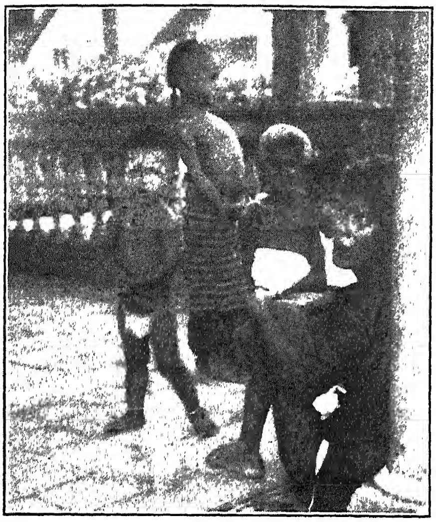
A STREET BY THE ROYAL PALACE IN BANGKOK
SHRUBS ARE GENERALLY TRIMMED IN FANTASTIC FORMS.



THE ROYAL PALACE
POINTS ON ROOF TREES EFFECTIVELY KEEP AWAY DEVILS.

rafts of teak float down from the forests in the interior. Handsome maids who live on barges dip up cups of water to drink or wash their teeth, and throw their household wastes into the long-enduring old mother. Dignified, modestly submerged dames with little nets dip up shrimps and drop them into floating pots while they gossip. Ferry boats of all sorts and sizes carry busy patrons. The sampans of farmers and fishermen are tied along the banks, while their owners offer their products for sale. Buddhist priests, clad only in startling yellow cloths, hold begging bowls. In the open field by the great palace grown men fly great kites. Wonderfully ornate palaces, temples and shrines rise above the roofs of the houses.

The Siamese, like most races, are something of a mixture. Their country has at various times been invaded and in part ruled by Burmese, Indians, Malays, Mons, Cambodians and Khmers, but the Siamese (Thai) came mostly from South China. Their general culture, as evident in literature, art and customs, has been influenced largely by India, and hence more remotely by Persia, but Siam has a culture all her own. The architecture and pictorial art are quite wonderful. Both men and women cut their hair short. The national costume includes a loose diaper, which is worn by both sexes. Hats which look like inverted dishpans are seen everywhere. The country is underpopulated, and perhaps on this account the people are disposed to be rather easy-going. The rice mills and other industries are largely in the hands of Chinese, and the Siamese laughingly say that they do not like hard work and are quite content to have it so. As one goes about every one he meets seems to be happy and con-



NATIVES OF SIAM

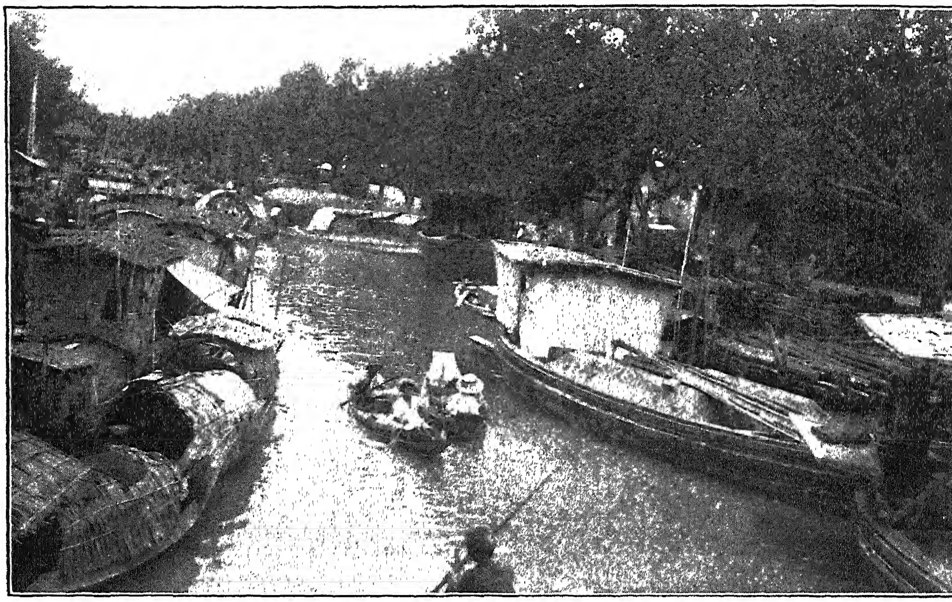
ABOVE, GIRLS AND BETEL CHEWERS; BELOW, MAKING PALM LEAF SHINGLES.

tented. The nobility are as a rule intelligent, educated and agreeable. The ambition of most peasants is to become attached to the household of some noble or wealthy man. The farmers are simple folk. Recent kings have for the most part been progressive and wise. Compulsory education is being rapidly extended to all parts of the country. Along with modern progressive trends some old and undesirable customs persist. Young men are required by law to serve two years in the army and three months as Buddhist priests before they reach the age of twenty-three. Women during childbirth are commonly tortured by being baked for hours beside hot fires. The chewing of a mixture of lime, the nut of the areca palm (betel nut; *Areca catchu* L.) and the leaves of the céri vine (*Piper betel* L.) makes the mouth and teeth of ordinary natives very hideous.

Though tin is mined extensively in southern Siam and a little gold occurs here and there, the chief resources are in native and cultivated plants and in aquatic animals. The extensive paddy fields in the alluvial plains are plowed with carabaos at the end of May and small rice plants from seed beds are planted. Palms and bamboos flourish in the lowlands; teak, rosewood and other valuable trees grow in the forests in the interior. Near water grows the attap

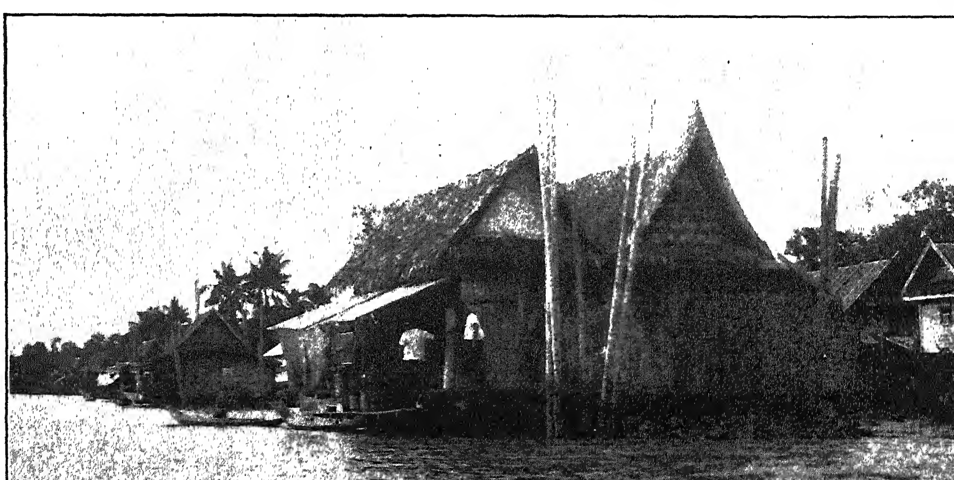
TEMPLE DOOR, BANGKOK

THE COLORS ARE TASTEFUL AND BEAUTIFUL.

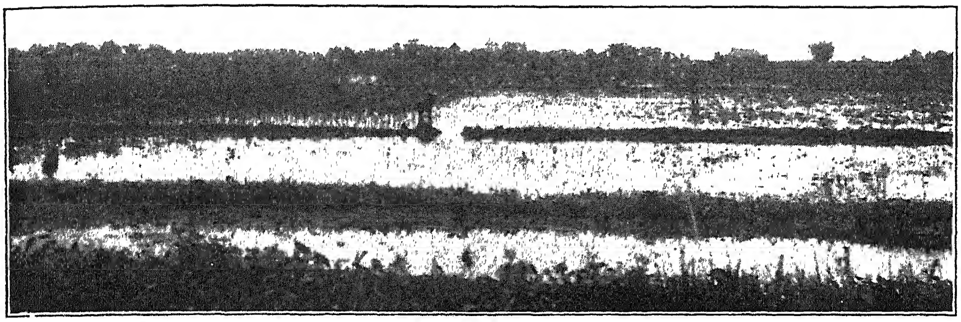


A KLONG MARKET
FARMERS, FISHERMEN AND MERCHANTS OFFER GOODS FOR SALE.

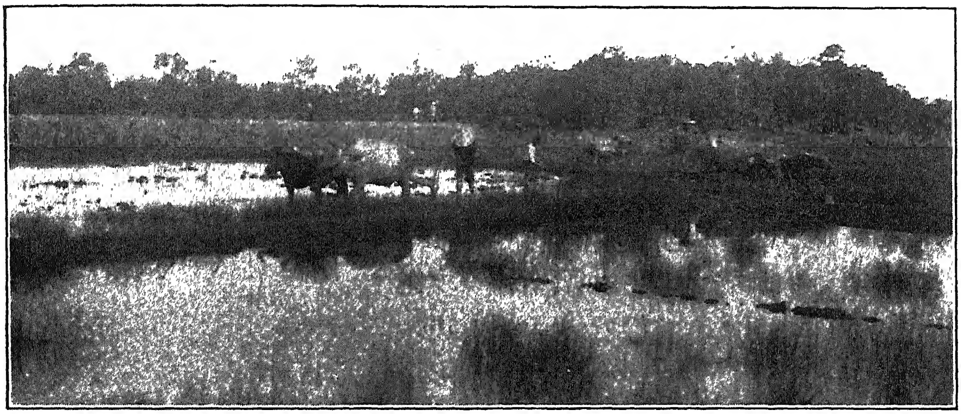
palm, which is used to thatch houses. A variety of fruits is commonly eaten. The cocoanut furnishes a refreshing drink, white flesh and sugar. A variety of bananas, mangoes, papayas, lamut, pommelo, melons, rambutan, linchi, langstart, oranges and lovely mangosteens are in the markets. The mighty and malodorous durian and jackfruit will astound those who have not met them. Imagine a custard + garlic, with a dash of turpentine and castor oil, and



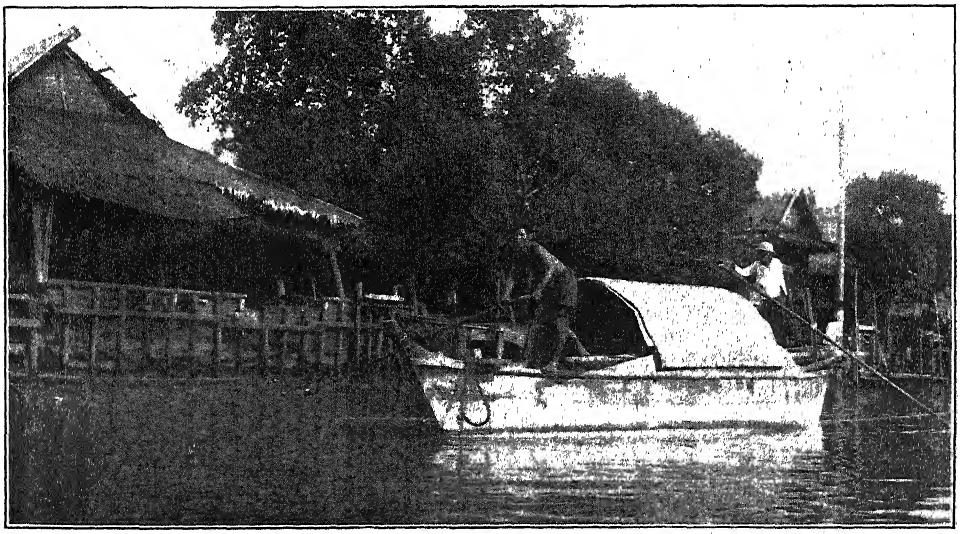
A STORE ON A KLONG
AN OLD LADY IS ARRIVING AT HER FRONT PORCH IN HER DUGOUT CANOE.



PLANTING



PLOWING
PLUMP DAMES WADE THROUGH MUD BEHIND CARABAOS.



A RICE BOAT
MANY SUCH BOATS CARRY RICE TO MILLS ALONG THE MENAM.

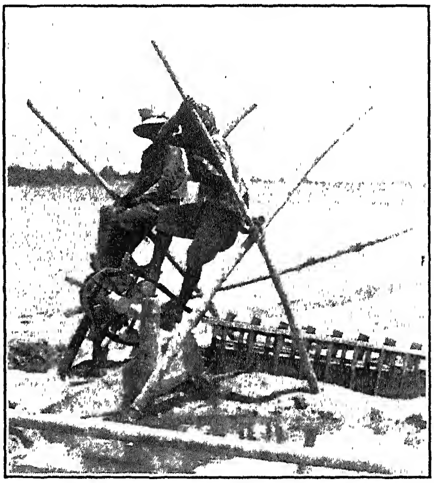
you have a durian. Yet those who have learned to like the prickly durian will have no other fruit and esteem it the "fruit of heaven." To my mind they are addicts.

Siam is an ideal place for the orchid hunter. There are also many beautiful flowering trees, among which the *ton pradu* (flamboyan, flame of the forest) never fails to charm. Roses, lotuses and jessamines flourish.

The fauna of Siam includes the elephant, tiger, leopard, boar, deer, gaur, rhinoceros, monkeys, gibbons, peacock, pheasants and other birds. Along the coast and in the streams and klongs a variety of fishes is to be found. The Mekhong is the home of the largest freshwater fish in Asia, the *pla buk*, which attains a weight of over 240 kilograms (530 pounds). The chief domestic animals are water buffaloes, humped-backed cattle, small Siamese ponies, pigs, ducks, geese and pariah dogs. In the markets near the coast various crabs, oysters and other sea foods are to be found.

For the naturalist Siam offers many opportunities. The seas, estuaries, rivers, klongs, rice paddies, fields, forests and mountains teem with life. At present Dr. H. M. Smith is scientific adviser for the Siamese government. He is making extensive collections and has already published several papers, especially in regard to fishes. In and near Bangkok he showed the writer several unique piscine spectacles. At his laboratory experiments are being conducted concerning the heredity of certain characters of the famous Siamese fighting fish. Specimens of this little fish are kept in separate glass jars with cardboards between. When a screen between two males is removed the pugnacious little fellows erect their fins; their bodies scintillate with a display of rainbow colors; and they bump their noses against the sides of their jars in frantic efforts to reach one another. When two males are placed together they fight until one of them is killed. Wrestling fishes have long beaks and two males will struggle for hours on end. Archer fishes shoot drops of water from their protuberant mouths and knock insects down to the surface from vegetation. A drop of water thus may be spit several feet with great precision.

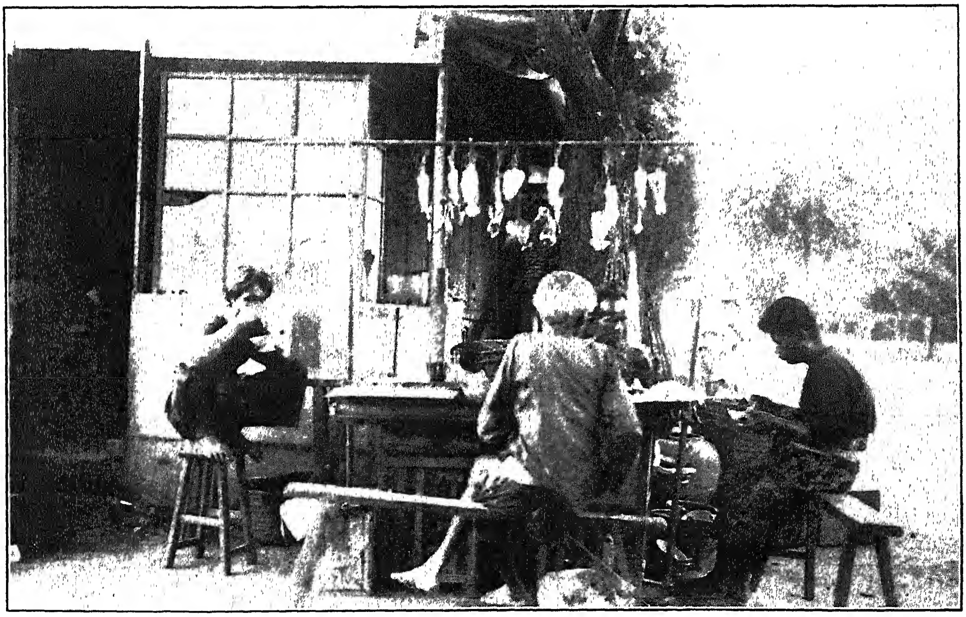
In Siam there are more than twenty species of fishes which breathe air. These will drown in from half an hour to two hours if they are kept under water and thus prevented from gulping in air from the surface. They have accessory respiratory organs of various types. These usually lie in special chambers above the gills. The climbing perch, *Anabas testudineus* (Bloch), often leaves klongs during rains and at night. A man may go home from a bridge party and find one of these fishes catching grasshoppers on his lawn. The serpentheads also make long journeys overland and live for as much as four months in dry mud. A Siamese farmer



A BOY AND GIRL ON A WATER WHEEL
SALTY WATER IS PUMPED ON ENCLOSED FLATS AND EVAPORATED TO OBTAIN SALT.

A FRUIT MARKET, WITH JACKFRUIT AND DURIAN IN THE FOREGROUND

often fishes by turning over his rice fields with a spade. He puts his catch of serpentheads in a bag and carries them to market. They may live there for days without water before they are sold. Various views have been held as to why in Siam and other tropical countries fishes have become air breathers, and periodic aridity has usually been supposed to be the primary factor in



WHERE MY MEALS CAME FROM; PAKNAM. DELECTABLE DRIED SQUIDS HANG BENEATH THE TREE

causing the necessary changes in structure and function. It has been shown, however, that in warm, shallow waters there is often a lack of oxygen and large amounts of carbon dioxide may be present, especially at night. So fishes are obliged to breathe near the surface or gulp in air. In Siam several species of fishes which never leave the water require air continually for their respiratory activities.

Cheerful, rotund, little Nai Pongse Phintuyotsin acted as guide and interpreter on a trip to Paknam at the mouth of the Menam Chao Phya, where we were able to study several species of beach-skipping gobies. These curious fishes live on mud-flats along the banks of rivers and dig holes in which they bring forth their young. There were three or four species of gobies which lived together at Paknam. A big fellow, *Periophthalmus barbatus* (L), lived largely on crabs and other fishes; a medium-sized goby, *Boleophthalmus bodaerti* (Pallas), gleaned filamentous algae for food by wagging its head from side to side over the surface of the mud; a little goby, *Periophthalmodon schlosseri* (Pallas), subsisted on mud, insects, such as ants, and little crustaceans. These gobies are adapted to life on land, especially in their locomotor and visual organs. They jump several feet and are very agile. Their eyes are unlike those of most fishes in being far-sighted, and are covered by a transparent protective membrane. Though beach-skippers drown if kept long under water, they can not live long in air without wetting their gills and branchial cavities. They are therefore at home on mucky flats, but often wander inland for a short distance among the attap palms or mangroves. After living where beach-skippers, climbing perch, serpentheads and crabs continually wander out of hot, shallow, oxygen-poor waters to take advantage of the high oxygen and food resources on land, it is easier to understand how aquatic animals gave rise to terrestrial types.

MAKING PALM LEAF SHINGLES

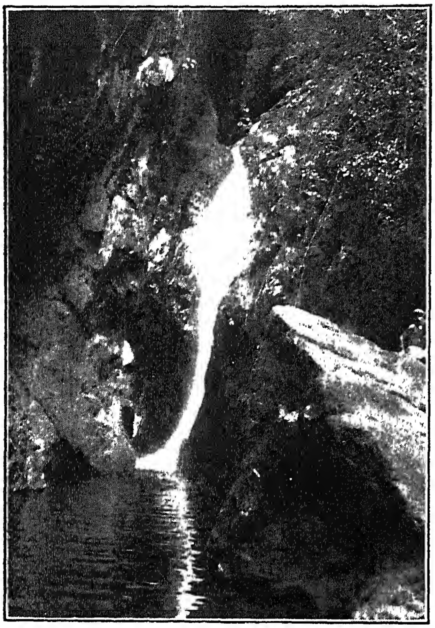
At Paknam we lodged with the governor's secretary and were courteously

received by his little wife, Laor. A traveler in Siam needs little but his bathing bowl and a cake of soap. Nai Pongse Phintuyotsin had a silver bowl ornamented with fantastic figures. I saved my face somewhat with an aluminum pan. With this each morn and eve I stood on the porch before a great jar of rain water and dashed refreshing showers over my soapy body. The children in the neighborhood always enjoyed this ceremony. My meals were delivered three times each day from a Chinese restaurant. The Chinese are born cooks, and I lived well.

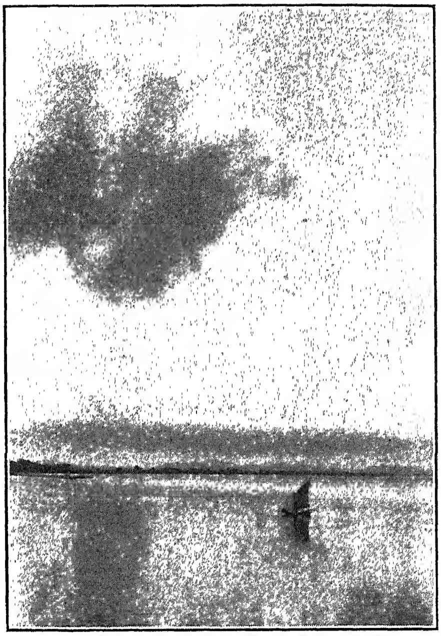
The most wonderful experience I had in Siam was a trip to Koh Chang (Big Elephant), a Siamese island near the coast of Cambodia. Koh Chang is about thirty kilometers long and ten wide. It is covered by a luxuriant rain forest. With Siri Habanananda and Gordon Alexander I slept among cocoanut palms twenty feet above the ground on the bamboo porch of the stilted house of a benign bachelor. The customs officer sent in hot rice for each meal and, with a grub-stake of canned goods, we did very well; until two days before we left, when a nice-looking little boy stole all our food. The work of the customs official did not seem to be very arduous. There were few imports except smuggled opium, and most of his work was in collecting the taxes on bird nests and turtle's eggs. On the way to Koh Chang we stopped at Chantaboon, and in an hour ashore I collected two apodous amphibians under stones and several fungus-beds of termites.

On Koh Chang the animals in the forest were wonderful. Great snakes chased squealing rats among the trees. In the luxurious palms about our house were flying lizards (*Draco volans*). These curious saurians have ribs which expand so as to support a membrane along each side of the body. They are

THE BOY WHO STOLE OUR GRUB–STAKE
HE STANDS BETWEEN SPROUTING COCOANUTS.



A WATERFALL IN KOH CHANG



CHANTABOON AT SUNSET

thus able to volplane from one tree to another. The dracos clung tightly to trunks even after I had shot them. To secure specimens I often had to use a long bamboo pole.

Along the mountain trails on Koh Chang were many land leeches. These lurked under leaves, and when one passed they emerged and looped rapidly forward. We kept a sharp lookout and removed them from our feet to bottles before we became anemic.

Most wonderful of all were the giant hornbills. These are the birds which are famous for their peculiar nesting habits. The male seals the female up inside a hollow tree with mud. While his mate is brooding and rearing young he feeds her through a narrow aperture. Thus he protects his family from snakes and other predatory animals. When I first heard a hornbill, I thought a railway train was coming. The swish of the great wings sounds much like a freight laboring up a long hill.

Siam is wonderful and pleasant. The people are cheerful and friendly. Tropical nature is at its best. In general the country is healthful. There are always such diseases as cholera, plague, malaria and dysentery, but with ordinary care a traveler is in little danger. Go to Siam!

HOW RATS TRANSPORT EGGS

THE RAT-EGG-WAGON STORY TRACED BACK TO 1291 A. D.

By Dr. E. W. GUDGER
AMERICAN MUSEUM OF NATURAL HISTORY, NEW YORK CITY

Introduction

In another article recently published,[1] I have given from old natural history books some fabulous stories of how various quadrupeds are used as animated carts in the transport of various materials. That paper (and this also) had its inciting cause in the faulty recollection of a lecture delivered during my student days at the Johns Hopkins University by Professor W. K. Brooks on Conrad Gesner, one of the earliest and greatest of the old natural historians. My recollection was that he told us that Gesner described rats as transporting eggs in this fashion—one rat with his four paws grasps an egg to his belly, the others roll him on his back, grasp his tail and drag him away. What Gesner did allege was that the Alpine mouse or marmot thus hauls hay, as described in my article noted.

In the course of years of checking up all sorts of bibliographies and the tables of contents of thousands of scientific journals, for titles for my card catalogue continuing the "Bibliography of Fishes," and in the course of an omnivorous reading of natural history books, I have noted a thousand and one titles of all kinds of interesting natural and sometimes unnatural history lore. Incited thereto by my (erroneous) recollection of Professor Brooks's account of the rats and the eggs, I have noted as they came to me accounts of how rats transport food materials, especially eggs. These methods are of two different kinds, and the accounts will be presented accordingly. There is no attempt to cover the literature exhaustively. I have simply noted what has come to me easily.

Rats are most ingenious creatures. Their brains have been sharpened by thousands of years of endeavor to outwit their enemies. These in nature are probably the smaller carnivores, weasels, etc.; but as semi-domesticated animals they chiefly have to fear cats, dogs and men. Living in and around the habitations of man, they have learned most skilfully how to despoil him of his food. Some of these ingenious ways of securing this food almost bear the marks of reasoning. Two of these ways will now be set forth.

As pointed out by M. A. C. Hinton, in his "Rats and Mice as Enemies of Man,"[2] rats are very fond of eggs and they show great cleverness in stealing them from containers and in carrying them considerable distances and over many obstacles. They will despoil a hen's nest and even steal the eggs from under a sitting hen. Generally these are eaten on the spot, but frequently the rats are desirous of carrying them away. Unlike birds which thrust the beak into an egg and so transport it, rats find eggs, because of their weight, shape and brittle shells enclosing semi-liquid contents, very difficult objects to handle. However, they are known to transport them without breaking the shell or even leaving a mark on it. How they are alleged to solve the problem will now be set out.

How Rats Carry Eggs

Saving for the final section accounts of rats serving as egg-wagons, those allegations that rats *carry* eggs upstairs and

[1] E. W. Gudger, Scientific Monthly, 40: 153–157, February, 1935.

[2] British Museum Handbook, Economic Series, No. 8, 1918.

down and on the level will now be presented.

Transport on the Level.—This method of transport will be considered first, since it seems to be the easiest mode.

One would think that the easiest way for rats to transport eggs would be to roll them along on the floor or on the ground. However, there is the handicap that it is impossible for them to roll a conical egg in a given direction. But there are two published accounts alleging that they do so. This is stated as a method by James Rodwell in his interesting book, "The Rat: Its History and Destructive Character" (London, 1858, Chapter XI), but he gives no details. However, one interesting account is given by C. J. Cornish in his "Animals at Work and Play" (London, 1896, p. 271), where he quotes A. Trevor-Battye that he had seen rats roll eggs by applying their chests to them. Cornish speaks of this well-known author as an acute student of the rat, but I have been unable to locate any papers on this animal by him.

The earliest account, which I have found, of carrying on the level is also in Rodwell's book. A rat was discovered in a hen-roost struggling with an egg, but so intently that it did not notice the observers. "Its principal difficulty seemed to be in balancing the egg; this it did by stretching out one of its forelegs underneath the egg, and steadying it above with its cheek. When thus secured, it hopped very steadily and cautiously upon three legs; thus looking in its action more like a young rabbit than a rat." When the rat neared its hole, the man gave chase and the rat to escape let go the egg.

The next instance of a like manner of transport on the level is excerpted from Tom Speedy's book, "Sport in the Highlands and Lowlands of Scotland" (London, 1886, p. 373). He states his personal observation as follows:

> Going hurriedly into a stable where hens were in the habit of dropping their eggs, we witnessed a huge rat bearing an egg along the manger towards its hole at the end. It hugged it with one of its fore feet, holding it against its breast, and in this manner was travelling [on three legs] along the outer beam of the manger. [On our] Making a rush towards the stall, it dropped the egg; but falling on straw it was not broken.

Before leaving this section, Ernest Menault's "The Intelligence of Animals" (English version, New York, 1870, p. 212) may be quoted as to the ingenuity of the rat. "On another occasion the rats formed a line, passing the egg along from one to another," as men pass buckets of water in fighting fires. No reference is given, hence this account can not be checked up.

Such a passing from hand to hand is shown in a fanciful picture (wholly the conception of the artist's imagination) in J. H. Collins's "The Ways of a Rat."[3] Here a rat, standing in a bowl full of eggs, picks up an egg in its paws and tosses it to a rat on the table. This one, holding it in its paws, passes it over to the next in line, and so on.

Transport Downstairs.—The first account of this kind of egg-carrying is from Rodwell's book. It seems that some especially fine eggs in a pastry cook's shop had disappeared and all the help were under suspicion. Watch was kept and here is what was said to have been found. Two rats, one large (male?) and one small (female?) were the discovered culprits. When first seen they were both on one step, about half-way down the stairs. What then took place is described as follows:

> When the big rat descended to the step beneath, he then stood on his hind legs, with his arms and head resting on the step above, till the other rat rolled the egg towards him: then putting his arms tightly around it, he lifted it carefully down onto the step where he was

[3] *Saturday Evening Post,* p. 36, August 1, 1925.

—*Photograph by courtesy of the Pierpont Morgan Library*

FIG. 1. THE EARLIEST KNOWN FIGURE (1291 A. D.) OF THE RAT-EGG-WAGON TRANSPORT

FROM A PERSIAN MS. IN THE PIERPONT MORGAN LIBRARY, THE "*Manafi al-Hayawan* OR DESCRIPTION OF ANIMALS" BY IBN BAKHTISHU.

standing and there held it until she came down and took charge of it, while he descended a step lower. Thus they passed from step to step till they were fairly at the bottom.

A most extraordinary method of downward transport, which he denominates "A Living Egg Chute," is described by J. H. Collins in the article previously referred to. This has been published before, but I have been unable to locate the book. It seems that there had been great loss of eggs (20 or 30 dozen eggs of a night) by rats which infested a storage warehouse, so a platform 8 feet high was built with legs of smooth iron pipe, and on this platform the eggs were stored. The eggs continued to disappear, so an observer was posted. He reported that the rats climbed on to a gas meter, which projected out from the wall at a height of 4 to 5 feet above the level of the table, which stood "8 to 10 feet off horizontally" from the wall.

From the gas meter, the rats are alleged to have leaped on to the table. If the edge of the table was 10 feet from the wall, this leap would have been about 11 feet (as a simple calculation shows). This is a long leap for an animal not built for such activities. But the observer reported that they reached the platform, and their next actions are described as follows:

> When they had gained the platform, these rats formed a chain to the floor, forelegs linked in hind legs [like the bridge alleged to be formed by monkeys over streams in South America]. It was a chain long enough to extend in an easy hollow curve [?] to a point on the floor some distance [?] from the platform, and the last rat in the line lay on his back. When this living egg chute was in place—and the animals worked as though they were performing an acrobatic act previously planned and rehearsed—things began to happen to those eggs. One by one they were lifted [?] from the crate, dropped [?] to animals on the platform, passed safely down the rat chain [in which all paws were occupied in holding fast] and away into the darkness of various rat holes.

This is a dandy story, which reminds me of a pungent criticism of a great public building—"Gorgeous in its ensemble, but faulty in its details." To be explained are an 11-foot jump out and away with a 4 to 5 foot drop onto a platform; the lifting of eggs out of a crate presumably 6 or 8 inches deep; the method of formation of this living chain; the tremendous grip on the edge of the platform exerted by the paws of the topmost rat necessary to support a 9- or 10-foot ("an easy curve") living rope of rats; the passing of 20 or 30 dozen eggs down this "living chute" of rats, each of whom was desperately holding on to the rat above with one set of paws, and onto the one below with the other set; and finally the method of dissolution of the living chain with safety to its component rats. This story is a work of art and imagination, but still it leaves too much to my feeble powers.

Transport Upstairs.—This is certainly more difficult than lowering eggs downstairs (save by the method just queried). There is but one account to be given. It is also from Rodwell, who quotes from the *Quarterly Review* (no date given and hence no possibility of verification) that rats carry eggs from the bottom to the top of the house by lifting them from stair to stair. The manner is described as follows:

> The male [?] rat stands upon his head [?], and lifts up the eggs with his hind [?] legs, when the female takes it in her forepaws and secures it till he ascends a step higher; and so they pass from stair to stair till they reach the top.

The position of the rat seems absurd. Possibly the account is intended for a hoax. If it is intended to be taken seriously, then the describer surely got his rat turned end for end.

Ernest Renault, in the work quoted above, speaks in a general way of the upstairs movement, saying that with mouth and paws one rat would raise the egg up until the other could receive it. Unfortunately, he gives neither details nor figure.

Rats as Egg Wagons

We now are come to those accounts or allegations which constitute the grand finale. These will be taken up chronologically.

The rat-wagon method of transport is an old story whose origin goes far back into the dim past. Dr. H. H. Donaldson, of the Wistar Institute of Anatomy and Biology, Philadelphia, Pa., has for 25 years been collecting notes on the behavior of rats. Appealed to for help, when I began the pursuit of this particular hobby, Dr. Donaldson wrote me that he had seen in an old Persian manuscript in the Pierpont Morgan Library of New York a picture illustrating this story. Application to Miss Belle da Costa Greene, director of this library, brought an immediate response in the threefold form of a photograph of the page in question, a translation of the part relating to the rats and a description of the manuscript. It is a pleasure to make acknowledgment of this courtesy, which is uniformly extended to students by the Morgan Library.

Fig. 1 is a reproduction of the photograph, the earliest known illustration of this old story. The text speaks of the

FIG. 2. THE RAT–EGG–WAGON AS FIGURED BY J. B. OUDRY

The rats are hauling an egg to get it away from the fox lurking in the background. The motive-power rat is pulling out of line with his fellow and is at a disadvantage. —From La Fontaine's Fables, Paris, 1759.

great cunning of the mouse [rat?] and the many tricks which it practises, and with regard to the figure says, in the translation by Abraham Yohannan, that:

> They have an interesting method of carrying away an egg; one of them lies down on his back and holds the egg with his hands and legs upon his stomach, another one takes hold of his tail and drags him towards their hole.

The painting is somewhat blurred, but the egg held on his stomach by the paws of the first rat is plain. The second rat has the tail of the first well up toward the root fast in its jaws and is pulling the first rat backward toward their hole, the opening of which is just behind the left hind foot of the puller.

This manuscript is thus characterized by Mr. M. S. Dimand, of the Metropolitan Museum of Art, New York City —"The earliest known manuscript of the Mongol period is the Persian copy of Ibn Bakhtishu's *Manafi al-Hayawan* or Description of Animals . . . [in] The Pierpont Morgan Library." The copier states that the manuscript "was finished with fortune and happiness in the city of Maragha [North Persia] on the eleventh of . . . 690." The name of the month is gone, but 690 A. H. corresponds exactly to 1291 A. D. and this may be assigned as the date of this interesting miniature.

This is the earliest known figure and account of the rat-egg-wagon story—644 years old. One wonders who old Ibn Bakhtishu was and where he got his story. Was it the outcome of his own observation or did he copy from some predecessor? Surely the imagination has free play here.

If the story of the rats and the egg was widely known in the East, one questions at once as to how it got into western Europe. Could it have been through the Arabs and Moors? This is conjecture only.

So far as I have found, none of the old worthies quoted in my earlier paper ("Animal Carts: How Marmots, Badgers and Beavers Serve as Sleds or Wagons") describe the rat-transport of eggs by the wagon-method. Knowing their fondness for such "tall tales," their absence from the old natural history books would seem to argue that this story was not known in those days. My error as to Gesner has already been noted. The history of the rat-egg-wagon story is then blank until one comes to the last quarter of the seventeenth century.

The next, and indeed the first modern rendition of our story known to me, is from the pen of Jean de la Fontaine. It is in his "Les Deux Rats, le Renard, et l'Oeuf" (No. CLXXXIX of his "Fables") which was dedicated to his patroness, Madame de la Sablière. This was first published in 1678.

The first figure (known to me) drawn to illustrate La Fontaine's account is from the pencil of J. B. Oudry. It forms the first plate of Tome IV of "Fables Choisies" published in Paris in 1759. It is reproduced herein as Fig. 2.

In none of the other French editions, examined in the New York Public Library, is there an illustration of this fable until one comes to the "Fables de la Fontaine avec les Dessins de Gustave Doré" (Paris, 1867, T. II, p. 195). Doré has two interesting drawings, duplicates save for size and intensity of color. The smaller and lighter colored is reproduced herein as Fig. 3.

For a charming translation of that part of the fable illustrated in these figures, I am indebted to an English version of the "Fables" published by Cassell, Petter and Galpin (London, 1878, p. 615). This reads as follows:

> Two Rats, seeking something to eat, found an
>   Egg,
>
> . . . .
>
> Full of appetite, nimbly they sat down to eat

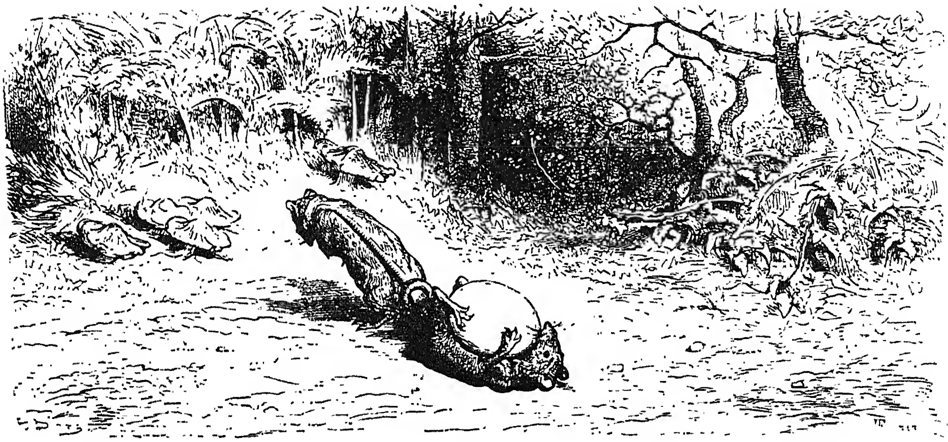


FIG. 3. GUSTAVE DORE'S DRAWING OF THE RAT–EGG–TRANSPORT

THE MOTIVE-POWER RAT HAS THE TAIL OF THE EGG-WAGON RAT OVER HIS SHOULDER AS A MAN WOULD HAVE A ROPE TO DRAG A HEAVY OBJECT. NOTE THAT THIS RAT HAS WOUND HIS TAIL AROUND THE BASE OF THE TAIL OF THE OTHER TO GIVE HIM A BETTER PURCHASE.
—FROM LA FONTAINE'S FABLES, LONDON, 1878.

And soon from the shell would have drawn out the meat
When a Fox in the distance appeared to molest them,
And a question arose, which most greatly distressed them,
No other, as you may suppose, but the way
The Egg from Sir Reynard's keen snout to convey,
To drag it behind them, or shove it before,
Were the plans tried in turn, but were all tried in vain
When at length the old mother of arts[4] made it plain
That if one on his back held the egg in his paw,
The other from danger could readily draw.
The plan was successful, in spite of some jolting;
And we leave the two sages their pleasant meal bolting.

These two charming figures deserve some comment. Each is of course the artist's concept of the author's account. In Fig. 2, Oudry shows the egg-carrier with his head and neck lifted clear of the ground holding tightly onto the egg. This is a very strained position, as the look on the rat's face shows. The draft-animal has laid hold of the other's tail with its paws and stands to one side as he drags his fellow along. This method is surely faulty, as may be seen on comparing Doré's figure (No. 3 herein). Here the carrier has his neck and the back of his head on the ground and is contentedly "leaving it to George." "George" has grasped his friend's tail with both paws, has slung this over his left shoulder and is pulling away for dear life. He has taken the very pose that a man would take in dragging a heavy load on the ground. The artist has put in another interesting detail—the motive-power rat has coiled his tail tightly around the base of the tail of his friend to give him a stronger hold on the egg-wagon.

So far as the data in my hands give us information, there is a long break in time after La Fontaine in 1678 till we come to the next publication of this story in 1803. There must have been other publications, but I have chanced on none. Fortunately my friend, Professor F. E. Clark, of the University of West Virginia, knowing my liking for what he

[4] Necessity.

FIG. 4. TWO RATS ARE DRAGGING THEIR LADEN FELLOW
NOTE THE HAPPY EXPRESSION ON THE COUNTENANCE OF THE SECOND MOTIVE-POWER RAT AND THE COCKY ATTITUDE OF THE TAILS OF BOTH.—FROM ST. JOHN, 1878.

designates as "unnatural history," has sent me a copy of "The Hive," a curious old newspaper issued at Lancaster, Pennsylvania. In Vol. I, p. 195, 1803, under the heading "Sagacity of Rats," are found some interesting stories. It seems that in Amsterdam, a certain householder kept fowls. One of his hens would cackle, but the nest was empty—no egg, no shell, no anything. Watch was kept. An egg was laid

> . . . but no sooner was she off her nest, than three rats made their appearance; one of them immediately laid himself on his back, while the others rolled the egg upon his belly, which he clasped between his legs, and held it very firm; the other two then laid hold of his tail and gently dragged him out of sight.

The next modern account which I have found bears the comparatively late date of 1854. In the *Zoologist* of that year (Vol. 12, p. 4285) A. C. Smith says that a "Mr. Bury assures us that [to transport it] the rat will grasp a hen's egg with all four paws, and then turned on its back will suffer itself to be thus with its prey dragged away by its tail to a place of security convenient for dining."

Next Rodwell (1865), who has been quoted above, gives without credence the following account emanating from Argyleshire, Scotland. Four rats were alleged to have rolled an egg away from a pile of such: then "One of the party, falling on his side, firmly embraced it with his legs; then being turned on his back, the rest yoked themselves to the burden, two in front [pulling] and one behind [pushing], and by this living vehicle they safely conveyed their booty to the hole."

This variant of the now familiar story introduces a new means of locomotion—propulsion by one rat in the rear.

Rodwell quotes another account, which he says was plainly intended as a "big story." One rat embraced the egg as above and the other dragged her along by the tail in conventional fashion until they came to an obstruction—a beam. Then was introduced an action which is inserted here in the light of what is to follow later. One rat climbed the obstruction and then dropped his tail to the other who grasped it tightly in her mouth (her paws being occupied in holding the egg). He sat on the beam

"and pulled up his mate, who held tight to his tail; then let her gently down on the other side." Then the wagon-transport was resumed.

Next comes one Henry Moses with a note, "Rats Carrying off Hen's Eggs," in the *Zoologist* (1865, Vol. 23, p. 9431). A rector of a parish in Westmoreland (England) reported to him that, having lost many eggs, he set a watch for the thief. On hearing a hen cackle, he observed two rats which came out of a hole in the hen-house and proceeded to the nest. There they rolled out an egg, one secured it in the fashion described and the other dragged this rat and the egg away.

Charles St. John, in his charming book, "Sketches of the Wild Sports and Natural History of the Highlands" (London, 1878, and 1893, chap. VII), comments upon the fact that rats transport eggs for some distances without breaking them. He asks how this is done, and then without a word of explanation, he closes his chapter with the annexed figure (Fig. 4 herein) as a tail-piece. Here is introduced a variant in that two rats furnish the motive power. They grasp their friend's tail in both forepaws and facing the animated cart back away from the scene dragging the other rat and the tightly held egg.

Next is an eye-witness account communicated to me personally in 1932 by Dr. W. E. Aughinbaugh, of the Explorers' Club, New York. At Caracas, Venezuela, about 1906, he was awakened one night and, looking out into the patio of his house, saw under a brilliant tropical moon a rat lying on its back and holding an egg between its paws. The white egg was plainly visible in the moonlight, and one rat was either pulling or pushing the other down a slight incline. His native servants told him that one rat always pulled the other by the tail, and that this performance was "costumbre del pais"—the custom of the country.

The next two accounts are from present day eye-witnesses. In May, 1932, I published in the *Journal of Mammalogy* an appeal for references to accounts of rats moving eggs and for first-hand information thereon. A letter came from Dr. Henry H. Donaldson, saying that among his data were two first-hand accounts. These he later sent me with permission to have them copied for use.

The first was communicated by Miss Mollie E. En Holm. She writes that, in 1897 or 1898, she was living in Pocantico Hills, Westchester County, New York. The winter's stock of potatoes kept dwindling, so watch was kept and the following observation made. "I saw a rat dragging another by the tail, which latter was on its back clasping tightly in its paws a large sized potato." Here the object is not an egg with a fragile shell enclosing semi-liquid contents, but a solid potato. One would have expected the rats to roll it along, or to sink their teeth in it and drag it along. Possibly, however, it was too large and heavy.

The other and final account in this article was communicated to Dr. Donaldson by Mr. Arch. E. Scott. The events occurred in September, 1929, at Stony Point, on the Hudson River. The continual disappearance of eggs and the frequent appearance of broken shells around the door of the hen-house (generally left open) led to the strong suspicion that the rats were the culprits. So Scott kept watch in the hen-house on a bright moonlight night. The door was closed and the wooden floor had but one hole in it—with claw marks on it. Scott settled himself on the overhead beams to watch. The disturbed chickens soon calmed down and all was quiet. The bright moon shining through the window illuminated the boxes in which were the nests and a 6-foot width of floor in front of the nest-boxes. As bait a very white egg was put in the middle box, which was about 7 inches deep. For nearly an

hour nothing happened and then—but Mr. Scott will tell the story:

> Did not hear rats arrive but saw one on floor and one going along the back of the boxes. The one on the floor jumped up, ran along edge of boxes and stopped at the egg. The other came back and both went around the edge of the box and slipped into the nest. Here they were lost to sight. Scuffling heard. One rat came back to edge of box. Leaned over gingerly and straightened up slowly. He (rat A) had the tail of the other rat (rat B) crosswise in his mouth. Lifted with skill till almost upright, and lowered rat B, which was clutching the egg to his belly, to the floor. The details of the operation could not be followed. There was no squeaking or other noise. Rat A jumped down, took tail of rat B crosswise in his mouth and dragged rat B across the six feet of illuminated space. In doing this, rat A walked forward and had the tail of rat B over his shoulder and the body of rat B close beside him.
>
> Rat B lying on his back was being pulled against the lie of his hair and was humped more or less into a ball. They moved towards the door sill but could not be seen after passing out of the moonlight. After they had gone a little way in darkness, the dragging noise stopped. Then came a sound like a gurgling squash. No scampering, but the rats came back and stopped motionless at the other corner of the nest-box, apparently thinking over the situation. Then they ran back to their hole in the floor.

Since the rats did not return, Scott climbed down. There was the broken egg with no tooth marks on the shell. He could not determine whether any of the contents had been eaten. When the occurrence was related to the farmer, he stated that rats transported apples and the like vegetable objects by setting their teeth in them and dragging or pushing. In this account the manner of lifting the egg-embracing rat out of the box containing the nest recalls the method of lifting the egg-holder over the beam recounted above.

It is interesting to note, what many readers have surely already had in mind, but what Mr. Scott only has called attention to, the fact that all accounts and figures have the rat-wagon pulled against the lie of the hair. This of course adds greatly to the friction. However, the tail offers a fine holding-on piece, much better than ears and snout.

As to the rat-egg-transport—"Believe It or Not." The alleged facts are quoted with meticulous care. With reference to his two correspondents Dr. Donaldson writes me that "With both my informants [Mr. Scott was a student at the University of Pennsylvania in 1929] I had considerable personal conversation, and I feel that their statements can be trusted, so that their observations may be used without reservations." And with them Dr. Aughinbaugh's personal observation agrees closely.

For myself I can only repeat Professor W. K. Brooks's comment when I reported before the seminar in zoology at the Johns Hopkins University in 1904 on A. C. Oudeman's book, "The Great Sea Serpent: an Historical and Critical Treatise." When asked what he thought about the existence of such an animal, he answered that "It is not safe to say that a thing does not exist in nature merely because neither you nor any other scientific man has as yet seen it." That is my attitude, and waiting for photographic evidence of a rat-egg-transport, I shall keep an open mind. "There are more things in heaven and earth than are dreamt of in our philosophy."

WILD LIFE OF THE FOREST CARPET

By ARTHUR PAUL JACOT

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Deer, jumping mice and the oven-bird are denizens of the forest floor by virtue of using it as their substratum, but there is also a host of curious animals which use the forest floor, especially the litter of dead leaves, twigs, branches and fruit parts, as their walls, ceiling and sub-basements. Looked at from the eye level of the cockroach, this litter layer becomes a several-story edifice of enormous extent. The various floors are separated by twigs, midribs, petioles, fruit husks, samaras, skulls, elytra and feces. The lower one descends, the more compact is the structure. The leaves become more fragmentary, the feces of worms, which have come up from the soil, of caterpillars which live in the trees and of the inhabitants themselves, as well as grains of sand brought up by the worms and a heterogeneous assortment of ant and beetle skulls and wing covers, become more abundant. This complex is rendered more intricate by the growth of minute fungus moulds which feed upon the dead leaves and other organic refuse, weaving it all into a compact mat by their myriad white hyphae. Thus is the woof woven into the warp of the woodland rug. And what of the moths and carpet beetles?

It is a matter of common observation that deer are more sparse than rabbits or white-footed mice. This is not due to their using different heights of trees for cover, but in part to the ratio between stomach capacity and available food supply and in part to the speed with which their respective enemies are able to quarter their habitat. It may not be generally known that in a state of nature not exploited by the white man, bears and wolves are less numerous than deer or that foxes are less numerous than rabbits. This is a result of availability of food supply. The territory of a grizzly is forty square miles, the territory of a red squirrel is five acres of woodland, of a vole a thousand square feet. In the forest carpet the same ratios obtain. There are forms of life corresponding to deer, rabbits and mice as well as bears, wolves, weasels, lizards, snakes and hawks.

In a more detailed review of these unfamiliar wild animals it will simplify matters if we restrict ourselves to a piece of carpet one square foot in extent and free from moss-plants and lichens. Naturally, such a restricted area will not, except by the merest chance, include such scattered and wide-ranging forms as deer (crickets and roaches), bears (carabid beetles), wolves (rove beetles), turtles (scarabid or dung beetles) and birds (various flies or bees nesting in the soil). Even the larger land shells will be overshot. This is another way of saying that by restricting our examination to one square foot we correspondingly and automatically restrict the animals we study to species measuring less than a quarter of an inch in length. Were we to take a square yard or meter as the unit, the animals would be increased in size to a length of one inch. If the unit were a square inch the fauna would dwindle in size to animals of a tenth of a millimeter or less. Similarly, having chosen the square foot, the lower size limit of the animals will be two or three tenths of a millimeter. A final observation is necessary. This size ratio is not really one of length but of bulk, so that an attenuated form like a threadworm (nematode), centipede or snake will fall in a size group lower than its length alone would indicate. Thus, although

we may exclude nematodes two to three tenths millimeters in length, we will include millipedes and centipedes half to one inch in length. The reason for this ratio of size of animal to size of unit area is that every non-parthenogenetic female of each free-living animal must be near enough to a mate to be able to reach him within her lifetime. As soon as the individuals of a species become so sparsely distributed that the females can not find mates (barring parthenogenetic species), reproduction of that species ceases. Thus volant animals can afford to be much more thinly scattered in the leaf litter than are non-volant animals of the same size. For instance, there is one individual of the minute feather-winged beetle (Ptiliidae) to every ten thousand mites of the same size. There is only one individual of the smallest Pselaphid beetle to every thousand springtails of the same size. In brief, springtails and mites must be much more numerous per unit area than volant insects in order to meet and mate. An exception is found in the land snails.

The total visible population of the square foot is made up entirely of arthropods, with a thin sprinkling of minute land snails. These animals, it will be noted, all belong to groups with a hard or dense outer coat-of-mail. Depending upon the depth or thickness of the carpet, the total number will vary from two thousand to twelve thousand "souls." The marvel is how can an average of nine thousand individuals large enough to be visible without a lens live in any and every square foot of forest litter without walking all over each other. It is a veritable greater New York, Paris or London. The possibility is largely due to two factors: availability and variety of food supply, and the use of skyscrapers which, due to a sacrifice of light, are not of the "built-back" type but continuous and bridged, over vast areas.

In a community one might ascribe importance, (1) to one individual, as in an anthropoid empire, (2) to the species having the greatest number of individuals, as pines in a pine wood, or (3) to a virulent species, as the chestnut blight fungus in a Connecticut woodland. Possibly the most important animal of the great plains in precolumbian days was the bison. Now it is *Homo sapiens*, white. In certain parts of Iceland and at certain times of the year the dominant species is the mosquito. Thus size alone is not an indicator of dominance—as in plant ecology. In animal ecology, on purely *a priori* grounds, numbers have been used as a pretext for labeling species as dominant or subdominant, seasonally or otherwise. That numbers affect a community is unquestioned, even if their only contribution through the ages is guano. Before any real evaluation can be made of any one species of a community, its function in that community must be determined. A species which shelters in a community for a limited time is not a dominant or even a sub-dominant, especially if dormant while there. In colonial days the passenger pigeon would devastate a piece of woodland chosen for its rookery by sheer weight of numbers. Nevertheless, it was not a dominant form of that woodland any more than a cyclone would be. As a lead, however, one may begin a sociological study by determining the function of the most numerous species.

In the case of the forest carpet there is one millipede, proturan, thrip or plant-eating insect larva for every thirty springtails or every fifty vegetarian[1] mites. In the case of the predators there is one centipede, ant, spider, pseudoscorpion, beetle or predaceous bug for every ten predaceous mites. Thus one can say that the mites and springtails are numerically the dominant groups. Whereas all other groups are numbered by units or tens, these two are numbered

[1] The term vegetarian throughout this paper includes saprophytic species.

by the hundreds (predaceous) and thousands (vegetarian). Among the springtails, there is always one or a few species in great abundance, while the other species are numbered by units and tens. The same is true among the mites.

Biologists explain this minority in the number of individuals of a species as due to their being out of their normal habitat, relics, of low fecundity or reproductive ability or as strongly held in check. In such cases the species can never hope to attain importance in that habitat or under that set of conditions. No matter how low is the reproductive ability it must always be enough to assure meeting of individuals for purposes of mating. Apparent rarity is due to ignorance, on the part of man, as to the exact habitat or niche of that species. Cyclic or seasonal rarity is not an average condition.

Out of a total population of one hundred and fifty species of jointed animals that may be found in any one square foot of woodland floor, at most ten only can be dominant or sub-dominant in numbers. The evaluation of the remainder is problematical. It is certain, however, that out of one hundred species of vegetarians (and saprophytes) in an area of such restricted choice of foods (dead leaves, dead wood, fungi, dead bodies, feces) there must be a great deal of duplication of feeding habits. Many unrelated species must feed at the same table. This is not specialization and diversity, but parallelism of habits. Sameness of feeding habits in such a restricted area is possible only because of the ever-renewed leaf and twig manna.

The food supply consists of dead leaves (grain), dead wood (potatoes, carrots and beets), fruit parts, bud scales and flower parts (beans, lentils, cauliflowers, tomatoes, spinach), pollen grains by the myriad, spores of mosses and fungi (fruits), caterpillar feces (cheeses), droppings of many animals (the entire sewage system of such an establishment) and the dead bodies of the community. Although there are no merchants, as the food is eaten in situ, there are undertakers and the night-soil brigade, even more beautifully developed than that of China. The work of one cast or guild is not done by the other. For instance, mites of the genus Odontocepheus are exclusively feeders on decaying, soft, punky wood. Whether they eat the wood for the nourishment in the wood (which is really decomposed by the intestinal biota) or for the fungal hyphae permeating the wood is not known. But it is certain that they push their subways for mite-mile after mite-mile along a dead branch or through an old log. Such species are the termites of the northern woods. They do not, however, frequent seasoned or dry wood but wait until fungi have rendered such wood soft and punky. They are never found outside of decaying wood, except by accident, or in moving from an exhausted supply to a fresh, or to find a mate after their own kind. The larvae of some deltoid moths feed exclusively on dead oak leaves. Certain species of springtails eat only spores. Certain mites are just as addicted to the use of predigested tidbits as is the holy beetle of ancient Egypt. The undertakers are the world's most practical—they eat the corpses. Thus there is no cemetery. The sewage disposers follow suit. Each after its own kind, one more particular than the other—with the exception of certain general feeders.

The food of most of the non-predaceous is not definitely known. Most of them have been regarded as destroyers of the leaf litter which would accumulate to the extent of several inches per annum if not destroyed. Such an accumulation would soon sour the land and kill its vegetation. These animals keep it full of holes, galleries and corridors, allowing water and air to circulate. They also reduce it to less highly organized matter, thus hastening soil fertility. Under certain conditions the predators

become too numerous and hold in too great check the litter reducers. Under other conditions the fungus eaters become too numerous and inhibit the development of the cellulose-decomposing fungi, so that the litter does not properly decompose. Under still other conditions the fungus eaters are so reduced in numbers that the fungus develops a dense, hard mat which covers the soil as a layer of papier-maché. All these conditions can be remedied to produce a soft black mull or a rapidly reducing duff. For this reason the artificial control and culture of the forest floor fauna is of direct economic importance, especially to forestry.

On the other side of the fence is arrayed the army of predaceous and parasitic species which average one to every nine herbivores. Millipedes are vegetarians, centipedes or predators. The minute Staphylinid and Pselaphid beetles, which are quite insignificant in numbers, feed upon springtails and possibly mites. Of mites there are at least three common predaceous groups. In fact, I find that of all the mites of any square foot one sixth are predaceous. Many of these predaceous mites feed upon springtails and possibly nematodes, as well as on their milder relations. Minute parasitic wasps are occasionally encountered. A group of mites more or less parasitic on larger mites and insects are abundant. And here also lies in wait the jigger.

In order to protect themselves from this horde of predaceous species, the springtails have developed the caudal springboard which, when released, catapults them through space. As such a mode of progression is useless inside a tenement, the inhabitants of the low-ceilinged lower levels are without or with rudimentary springboards, while the habitués of the roof garden have them so well developed as to enable them to clear an entire level (leaf) at one spring. Exceptions occur, as elsewhere in life. A second mode of protection or adaptation is size and shape. Dwellers near the soil are smaller and depressed and can slip through much smaller doorways and down more low-hung runways than their pursuers. Per contra, the sky gazers are considerably larger and have compressed bodies, often garnished with a heavy suit of their own hair. Another protective device particularly developed in some of the mites is B. O.

The mites, having set forth in Precambrian time to reduce the length of their bodies, could not break their tradition by the development of caudal appurtenances. Instead, the largest group, like the beetles, developed a dense coat-of-mail. Having pushed their tradition of reduction of body length so far as to have lost almost every vestige of body segmentation, their coat-of-mail lacks transverse joints. Like the turtle, the entire body is enclosed in a dorsal and a ventral carapace but so constructed that the lower fits under the rim of the upper. Thus clipped in, they are quite impervious to sucking probes. Their only enemies are therefore internal, including fungi, and animals that can swallow them whole. To protect themselves from such much larger animals, snuggling into crannies, fissures and pores has become their habit and to such an extent that it is difficult to find them in their natural habitat even with a hand lens. These mites outnumber all other animals of their habitat two to one, because of their extremely slow rate of locomotion. In fact, if a he-man-mite were separated from a lady-mite by a log one foot in diameter it would take him an hour to reach her if he could travel in a straight line up over the log and had no floor leaves among which to meander. Springtails, with two legs less and a much longer body, are ever so much more rapid walkers.

As a result of having to live generation after generation in the darkness of the sub-basements without electric lights

or phosphorescent organs, about three quarters of the population are eyeless. This condition obtains in all the herbivorous mites (five thousand) and two thirds of the springtails (two thousand). Other sense organs, however, are highly developed in some groups. Loss of eyes has been accompanied by loss of pigment, with the result that two thirds of the springtails of these lower layers are white, while a large proportion of the mites are of pale coloration to white. As one ascends, springtails with pigment become more numerous, so that on the roof-gardens (the loose leaves on top) the springtails have variegated colors and bizarre color patterns and are larger and much more vivacious. This enhanced and sprightly life with its colorful camouflage is necessitated by the momentary possibility of the alighting of aerial coursers such as predaceous flies, bees and beetles or the sudden whipping in of racers like the ground spiders, daddy-long-legs and other large carnivores. Then must every herbivore know the location of each scuttle, door and screen. Where the forest canopy is the least bit open this life is chiefly nocturnal. Why, then, such wealth of color? Perhaps to these animals with their compound eyes and eyes of various colors, *tous les chats ne sont pas gris*, and they are able to recognize patterns if not colors. Or perhaps they are more crepuscular than nocturnal.

One of the outstanding features of lower Manhattan is the diurnal human tide which ebbs and flows through the lower levels. The motion is chiefly lateral and governed by the chronometer. In the forest carpet the tide is as marked, but vertical and governed largely by the barometer, hygrometer and/or photometer. We do not know if the hordes are moved directly by changes in atmospheric pressure, but we do know that they occupy different horizons during different moisture conditions. Night, with its greater coolness and moisture, causes greater activity among the upper layers, daylight causes a descent. Advance of frost with its drying effect also brings on geotropism. For instance, the minute land snails, of which there are from three to twelve species, depending upon the type of woodland, take to the soil on the advent of frost or dryness. Other animals, often a particular species or genus in any one group, are quite resistant to drought, while others are very hygrotropic. Among the vegetarian mites, active species (as in Liacarus) are very sensitive, while slow species (as in Nothrus) are very resistant—which is as it should be, according to the law of survival. Of the five species of thrips common in leaf mould of the blue ridge region, one species is found chiefly and typically in the upper, drier layers; one is found chiefly in pine leaf mould, and the other three in the lower layers. These may have special feeding habits.

Like us, these animals, at least most of them, keep their eggs in cold storage. The region of their domain which is most constant in temperature (and humidity) is the soil. Hence the gravid dames descend to the soil layer to parturate their unborn young. As the laying season extends through the growing season, forest fires do not exterminate the fauna, though it leaves the newly hatched young with extremely little food and shelter.

So extensive a society is not without its characters. Don Quixote is here called the pseudoscorpion. Most of our pseudoscorpions reach a length of three millimeters. They are armed with two large pinchers on the front of the head and two huge, crablike nippers held out at the sides of the head. Thus they have a frontal battery unexcelled by any other denizen of the square foot. If touched they make a precipitous retreat running backward with great agility. I suspect they only chase what runs from them. If you see a hill slowly rise and

walk off on four pairs of stout, bowed legs you would understand that a species of the mite Camisia is making off with its load of accumulated trash, for, like some Reduviid bugs, Camisia has learned to blend itself to the landscape by carrying a part of its background on its back. When you see a crinkle-surfaced caterpillar feces move slowly off, you should appreciate the protective sculpturing and coloring attained by mites of the subfamily Carabodinae. The vender of palm fans (*Phyllotegeus palmicinctus*) carries its wares in concentric circles on its back. Cepheus, the vender of halberd heads, similarly displays its goods. The box turtles and armadillos are represented by the Phthiracarid mites, which draw their eight legs into the anterior end of their abdomen and then cover them up with their trench-helmet covered heads. The Galumninae have diverged from all other groups of the animal kingdom in that they have developed bilateral wings resembling apple petals behind which they enclose their legs. Short, squatty forms in blues, yellows and violets, which spring like frogs when touched, but ever so much further (for their size) are Sminthuroid springtails, while the other springtails are more like grasshoppers and crickets. Stiletto Pete (Bdella) in his ruddy skin darts here and there with his dagger held ever before him ready to strike and suck. Minute spiders, with their six to eight eyes, on a conning tower quarter the concourses for anything that moves. Scarface Al. (Gamasid mites) slinks about with a pair of hedge shears held ever before him ready to clip the flight of juicy springtails. Most formidable of all are the dragons (centipedes) whose long, sinuous, many-legged bodies flow in and out of the corridors, feeding on any moving object. The short ones (Lithobioid) run most rapidly, while the long ones with three times the number of legs (Geophiloid) run most slowly. Hawks (the minute parasitic bees) come darting down, stab an egg into their victim and are off so quickly the victim is all unaware of the Jekyll which will develop within him. And this is the life that any one of us covers with his two feet on any woodland floor.

SOME OLD BIZARRE MEDICAL REMEDIES

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Introduction

Since the day Pandora lifted the lid of the pestiferous box, methods and means of combating disease have rapidly accumulated. A few active remedies were stumbled upon in the course of time, but they were almost totally submerged by the great mass of their inert competitors, so that long before the Middle Ages the *materia medica* included almost everything under the sun. Some of the ingredients of Shakespeare's witches' cauldron were, as might therefore be supposed, not confined to the elixirs with which hobgoblins and their ilk tried to convert the golden hearts of the elect to dross but were allotted places in the apothecaries' shops among such things as centipedes, horse dander, mummy and scores of other things of equal rank. An apothecary indeed had to be a valiant man with no too squeamish stomach, for many a mess he had to prepare was, in truth, "so loathsome that one would expect to see the worst disease leave the body in haste to escape the contamination."

The basis of the therapeutic art in those dark ages was, of course, the medical system of Galen, bad in itself and much corrupted by an admixture of old wives' lore and other humbuggery. When the Arabian alchemy penetrated into Europe, there came with it a few good remedies which had been run across in the hunt for the philosopher's stone.

Most of the material of the present article will be found to be drawn from sources of the seventeenth century—a very active and familiar time of the world's and especially of England's history. It is the time of Shakespeare, Jonson, Charles II and Samuel Pepys, Robert Boyle, etc. It is the age, moreover, which saw the culmination and the beginning wane of the old medicine and indeed of the whole philosophy which had ruled the world for two millennia. In its early years Galileo with his home-made telescope made some remarkable discoveries. About the same time Dr. William Harvey demonstrated the circulation of the blood. But it took a great while for these and other enlightened empirics to make an impression on the rank and file of their reactionary associates. The attitude of the time is well illustrated by the fact that Harvey let twelve years pass before he dared publish his work for fear of ridicule. The universities were still citadels of conservatism. There one was informed that the elements were earth, air, fire and water, and perhaps a few others. In the medical classes one heard explained that disease was an inbalance of the humors or was due to an unpropitious conjugation of the planets.

But about the time of the Commonwealth and the beginning of the Restoration in England, fresh blood began to flow through the ancient cadaverous body of learning, and with the advent of the Royal Society and its purging influence some of the erstwhile prized treasures went to pot. Philosophy and mysticism gradually began to be replaced by investigation and experiment. In the medical field the study of anatomy took a great step forward. Therapeutics also began to advance, but being rather ponderous it moved more slowly, and the Galenic herbs and motley array of medieval drugs persisted far into the following centuries.

Charms and Incantations

Though improvement in general was slow, magic charms and incantations, at least, were falling into disrepute. They were still in popular usage, but the reputable members of the medical profession had ceased invoking the supernatural in their attempts to cure. But as these represent the healing art in the full strength of its pristine crudeness, it may be well to begin by citing a few of them.

In the famous "Compendium Medicinae" of Gilbertus Anglicus, written at the time of Richard the Lionhearted, and very popular for several centuries, the following sure cure for impotence is recommended:

> Let a man twenty years of age or more, before the third hour of the vigil of St. John the Baptist, pull up by the roots a specimen of consolida major [cumfrey] and another of consolida minor [heal-all] repeating thrice the *oratio dominica* [Lord's Prayer], let him speak to no one while either going or returning, say nothing whatever, but in deep silence let him extract the juice of the herbs and with this juice write on as many cards as may be required [*i.e.*, to use up the juice] the following charm:
>
> *Dixit dominus Crescite.* †. *Uthioth.* †. *Multiplicamini.* †. *Thackehay.* †. *et replete terram.* †. *amath.*

It was to be used as an amulet. The meaning of the words is, in so far as they have a meaning: "The Lord said, Be fruitful and multiply and replenish the earth." The parenthetical expressions, between the signs of the cross, have a Hebraic ring, but the author is able to make nothing of them. At any rate, to replenish the earth is a large order, though perhaps not excessively so, for the charm was very potent, which is seen from the fact that the author deems it necessary to warn against the dangers of satyriasis which might accompany it, and sets forth suitable precautions to forfend that occurrence.

The above is, of course, a translation from the Latin, in which most books of the time were written, but what follows is a quaint one from an English book of the fifteenth century. It is for epilepsy:

> Take xij candylls of ye length of ye chefe joynt of ye hande, and the xiij candyll as long as the iij of the sayd xij and gar synge [cause to be sung] on[e] messe of the holy ghost, and gar lyght [cause to be lighted] the sayd xij [xiij] candylls, and apun every candyll wryhte on[e] name and apon the large candill jhc,[1] and apun the ryght syd sante petur and apon ye lyeft syd sante paulle, and apun yelke [each] on[e] of ye oyer [other] candills sette a name of the xij apostylls, so that vj stand on the on[e] syd and vi apon toyer [the other] . . . and heyd [notice] whilk of the candills endure the longest, and to the same appostyll the seky [sick] body must woue to fast the evyn to brede and water while he levys.

This, perhaps, is not altogether bad advice, for epileptics who have attacks with especial frequency at night are often benefited by going to bed on a relatively empty stomach and one is not apt to gormandize on bread and water. For this same condition the previously quoted Gilbertus Anglicus recommends a concoction of ants' eggs, scorpion oil and lions' flesh. If this were made the principal article of diet it would be of the order of the low carbohydrate diet recently advocated for the same condition.

Amulets

Into a class similar to magic incantations belong amulets. They appear to have been used from time prehistoric, and they were very popular in medieval Europe. They consisted of dead men's teeth, animal bones, curiously shaped stones, gems, parts of plants, wrought objects, as the sacrament shillings (coins collected in churches on Easter Sunday), verses of holy writings, religious phrases and the like. The famous jingle, abracadabra, was one of these. Ordinarily it was just hung about the neck, but in

[1] jhc: Probably an attempt at translating into Latin characters the first three letters of the name Jesus in Greek, sometimes seen in modern church decoration thus: ΙΗΣ. The latinized form is probably the source of the ribald expression, Jesus H. Christ.

urgent conditions best results were obtained by rolling the parchment into a bolus and swallowing it. The etymology of this bit of jargon is said to be from the initial letters of the phrase "Father, Son and Holy Ghost," in Hebrew (Ab, Ben, Ruach [H]Acadosh).

As has been already indicated, at the start of the seventeenth century things of this sort were well on their way to desuetude, at least among the more responsible members of the profession. Patients then, as now, desired something tangible, as pills, potions and plasters in return for their physicians' fees, and incantations became a rather poor source of income as the firmly entrenched superstitions of the Middle Ages began to loosen on their foundations. Though obsolescent, they were by no means obsolete, as the following amulet suggested by the learned Dr. Bates, "physician to two Kings of England and a Protector," attests. It is called "Turquis Infantum."

> It is made of the male Peony-root and Henbane-root, fresh-gathered, cut into round pieces and bored thro' the middle and strung in order upon a Thread or String, which being wrapped in a fine Linnen or Lawn, are to be worn about the Neck in the time of breeding Teeth. They are said to facilitate the breeding of Teeth and to prevent Convulsions.

The recipe for this necklace came from Bates' "Dispensary." Dr. William Salmon, who revised and enlarged the book in 1694, comments as follows:

> It is to be used as an Amulet, in which I believe there is no more Vertue for driving away Pains in the breeding of Teeth, than there is in the words being worn about the neck as a Pentacle. But for such as have Faith in the thing (and I know not but Faith may do the Work) they may put it about their Childrens Necks, and let them wear it as long as they are breeding their Teeth. If in this Time the Child should be cross and froward and peevish, with the anguish of its Teeth cutting, the Parent or Putter on thereof must wholly blame themselves (and not the Medicine) for that they were people of little Faith.

Discussing another such prescription from Bates, named "*Amuleta Pestilentialia*" (amulet for the plague), consisting of a few crushed drugs to be put into a little bag, Salmon very generously recommends the addition of a little mucilage to hold it together. "Paracelsus and others," he continues, "are of the Opinion, that there is a mighty Powr, Force and Vertue in such like Amulets to defend against the infection of the Plague. However," he goes on,

> I will say, that if my own Life lay at stake, I should rather trust to some known Specifick Antidote than to all the fam'd Amulets in the World, tho' if the Philosophick Reason of the thing be considered and inquired into, there may be much more in it than many are aware of.

Here Salmon seems to be anticipating the supposed modern discoveries concerning the power of suggestion in treating disease or, at least, in treating some of its symptoms. But it seems reasonable to suppose that observing men must always have known this.

Shot-gun Prescriptions

Paracelsus, "the brilliant, brawling Bombast of Hohenheim," complained that "the apothecaries are my enemies because I will not empty their boxes. My recipes are simple and do not call for forty or fifty ingredients." It was indeed the heyday of polypharmacy or shot-gun prescriptions, as they are often called. Medicines were compounded of a multitude of drugs, probably with the hope that at least one of them would be effective. At present, drugs not strictly essential are sometimes added to prescriptions because it has been found that certain combinations of drugs mutually enhance each other. Such drug action is spoken of as synergistic. That anything was known of this in the seventeenth century is unlikely. But perhaps they suspected something similar, for the irrepressible Porta, in his "Magia Naturalis," advises for the purpose of mak-

ing insipid musk recover its scent to "hang it into a Jakes [privy] and among the stinks; for by striving aginst these ill savours it exciteth its own vertue." It may be that they thought medicinal agents were enhanced by a similar competition among themselves.

As the words of Paracelsus suggest, it was nothing unusual for a remedy to contain forty or fifty ingredients. The biggest charge perhaps ever ordered for a pharmaceutical shot-gun was "Matthiolus, his great Antidote against Poyson and Pestilence," which was used from the sixteenth century well into the eighteenth century. It specially mentioned 130 ingredients, ranging from rhubarb to emeralds. Some of the components of this mixture were complex in themselves, so that all told the number of substances comprising it must have approached 200. This prescription was a marvel even in its own day, and the physician Culpeper made the remark that if the formula "were stretched out and cut into thongs it would reach around the World." There was little irony in this statement, for he recommended the recipe as excellent for its intended uses.

Precious Stones, etc.

The heterogeneity and scope of the pharmaceutical armamentorium of the Restoration is well illustrated in the following prescription given by Bates. Its name is *"Lapis Contrayerva,"* a diuretic plant.

Magisteries [powders] of hartshorn,
of white and red Coral,
of Pearls,
of White Amber,
of Crabs Eyes, of each, 2 drams;
Roots of Contrayerva ½ dram;
the black points of Crabs Claws 2 ounces;
all rightly prepared; mix them together, and with Gelly of Vipers, as much as is necessary, to make it up into little Balls, which cover with heavy leaf Gold and carefully dry, according to the art. Some add to the composition Ambergres 1½ drams. It is a famous Cordial, Antidote against Poyson and Sudorifick, prevails wonderfully against the Plague, Small-pox, Measles, and all sorts of malign Fevers. Dose ½ dram.

The next is from the same book and is somewhat similar, though likely more costly. It is called *"Lapis de Goa."* Goa is a plant, a crocodile and a city in India.

Of the Hyacinth,
Topaz,
Saphire,
Ruby,
Pearls, of each, 1 ounce;
Emeralds, ½ ounce;
Oriental Bezoar,
white and red Coral, of each, 2 ounces;
Musk,
Ambergrise, of each, ½ ounce;
Leaves of Gold, No. 40;
make all into a fine Powder, which bring into a paste with Rose-water and form into oblong balls not much unlike to little Eggs, drying them well in the Shaddow: then with a Limpets Shell, or some other thing of like nature, let them be carefully polished that they may have a Gloss upon them, according to the Art. It has the same virtues with the former. Besides which it is a Specifick against Cramps and Contractures of the Nerves.

If we could give credence to the words of Dr. Salmon these would most certainly be potent pills, for he adds:

> It is an Antidote against Plague and Poison and cures the Bitings of Serpents, mad Dogs, or any other venomous Creature; it revives the Spirits, cheers the Heart, fortifies Nature, resisteth Melancholy, restores in Consumption, prevails against all Diseases of the Head and Brain, proceeding from Cold and Moisture, causing a lively Presence, nimble Wit, a pleasant Countenance and a sweet Breath.

Of course it will do nothing of the sort, except perhaps correct halitosis for a time. Most of the ingredients are absolutely insoluble, and the whole pill is so constituted that it will, most likely, pass through the system intact, much as the "everlasting pills" of metallic antimony of the same period, which were used by the whole household and

bequeathed from one generation to the next.

Precious stones were prized for all sorts of conditions. As they were only in reach of the rich there were substitutes to suit the purse. If a prescription called for emerald it could also be gotten with green glass. It wasn't quite as good, it is true, but that couldn't be expected. The London Pharmacopoea, as revised by Culpeper in 1683, gives the virtues of,

> Emerald, called the chast stone because it resisteth lust. . . . Being worn in a Ring, it helps or at least mitigates the Falling-sickness and Vertigo. It strengthens the memory and stops unruly passions of men. It takes away vain and foolish fears, as of Devils, hobgoblins, &c. and causeth good conditions; and if it do so being worn about one reason will tell him, that being beaten into a powder and taken inwardly it will do much more.

Personally Culpeper had his doubts, for he concludes the chapter with, "Thus I end the stones, the Vertues of which if any think incredible I answer, 1. I quoted the Authors where I had them. 2. I know nothing to the contrary but why it may be as possible as the sound of a Trumpet is to incite a man to valour, or a Fiddle to dancing." In other words, he means to say that the value of these indestructible medicaments is psychological alone.

Detoxifiers

Bezoar, mentioned in a previous panacea, like ambergris, was an intestinal concrement, but derived from certain herbivora instead of from whales. Notwithstanding its ignoble origin, it could well be put into the category of precious stones, for it was worth many times its weight in gold. Bezoars had been popularized by the Arabian physician Avenzoar in the twelfth century. The name means "expeller of poisons," and detoxification was their chief alleged virtue.

Besides being taken internally, they were preserved as charms in gold and silver caskets. During the plagues they were rented out for large sums. An eastern nabob once sent one to Queen Elizabeth of England. Later, bezoars were discovered in Europe, but, as is usual, the domestic variety was considered inferior to the imported.

Somewhat related to bezoar in its usefulness was the horn of that *rara avis in terris,* the unicorn. Its field of operation was also detoxification, and it worked as effectively outside of the body as within. Horns of this fabulous animal were in especial demand by royalty who were in constant fear of imbibing some subtle *poudre de succession,* surreptitiously added to the royal beverages. The hollow unicorn horns were a very good protection against the consummation of such dark forebodings, for all that was necessary was to allow the liquor to stand in one of those magic containers a short time, and old King Cole might enjoy his pipe and his bowl and his fiddlers three without any sinister ruminations to mar his evening's fun. Some one gave Henry II of France one of these horns which was seven feet long, large enough by all odds to innocuate several bootfuls at once.

Shortly after the start of the whaling industry the unicorn horn vendors must have turned their mercantile talents to things like the London Bridge. At any rate their business must have gone to pot, for a pharmacists' dispensatory in 1733 informed the erstwhile duped world that "the Unicorn . . . is a great fish found in Davis' straight." It goes on to say that "what's commonly sold for Unicorn's horns is nothing else but bones of Whales, Sea Horses [walruses], or Elephants, which are brought by art into that shape."

Dabblers in Medicine

Up to the middle of the eighteenth century there had been many physicians of well-deserved fame who were not doctors of physic at all but merely "stu-

dents of physic,'' as they liked to call themselves. Even more numerous than these were those who just dabbled with medicine. It was not till 1748 that Parliament restricted the practise to those academically qualified. The celebrated Nicholas Culpeper himself entered the profession *via* the apothecary's shop and never had a degree; yet he was the author of half a dozen medical books which were very popular in England and colonial America. Perhaps the most notable dilettante of this sort was the Hon. Robert Boyle, F.R.S., the renowned ''father of Chemistry.'' In the great and protean list of his publications is a little book entitled ''Medical Experiments, or a collection of choice and safe Remedies, for the most part simple and easily prepared: Useful in families and very serviceable to country people.'' Boyle was without question the most famous scientist of his day, and his exceptional ability might give rise to the expectation of finding in this volume some real improvement over the advice offered by his contemporaries. But alas! about the best one can say for his remedies is that they are simple, though perhaps, in a different sense than he intended.

His advice ''To clear the Eyes from Films'' goes that somewhat paradoxical, popular expression of benevolence, ''Here's mud in your eye!'' several better and even attempts to put it into practise. It directs that one

> Take Paracelsus's *Zibethum Occidentale* (viz. human Dung) of a good Color and Consistence, dry it slowly till it is pulverable; then reduce it into an impalpable powder; which is to be blown once, twice or thrice a day as occasion shall require, into the Patients Eyes.

Boyle graded his recipes alphabetically, according to their supposed values. This one ranked an A. Doubtless the afflicted ones were not supposed to guess what sort of treatment they were being subjected to under the high-sounding name of *Zibethum Occidentale.* Suffering with a malady of such a nature, Boyle perhaps supposed they would not be able to read his parenthetical explanation of the term. Otherwise one might imagine that they would utter a determined protest, as did the prophet Ezekiel when Jehovah ordered him to bake his food with this material. (See Ezek. 4: 12–15.)

To most people the pungent odor of the genuine civet is anything but pleasant, but it may well be imagined that, instead of going to the ''jakes'' for ''occidental zibet,'' the afflicted one would be willing to tap his cane along the broken pavements and mud-gutters to the nearest chemist's shop and say: ''Give me a dram of civet, good Apothecary.'' Nor would he forget to add, ''And I don't want anything 'just as good' either.''

One is tempted to say it is eminently fitting that the great Boyle should prescribe for little boils and kindred evils. Here is a first-class formula ''for Ulcers of the Breast and elsewhere:''

> Take *Millepedes* (in English by some called Wood lice, by others Sows) and having washed them clean with a little White-whine and dry'd them in a Linnen Cloth, beat them very well in a Glass or Marble Mortar (for they ought not to be touch'd with anything of Metal) and give the first time as much juice as you can by strong Expression obtain from 5 or 6 of them. This juice may be given in small ale or White-whine, in which the next time you may give as much as may be squeez'd out of eight or nine Millepeds; and so you may continue, increasing the number that you employ of them by two or three at a time till in amount twenty-five or thirty; and if need be forty or more for one taking.

Perhaps the *rationale* of this treatment was that the ulcers would take legs unto themselves. At any rate it seems to have been a good cure, for in the ''New English Dispensatory'' of 1733 ''that honour to our country Mr. Boyle'' is commended for it, though he, no doubt, was not the originator.

''For Difficulty of Hearing from a

cold cause'' this eminent savant suggested:

> Out of the Bulb or Root of Garlick, chuse a chive of convenient Bigness; then having pass'd a fine piece of Thread or Silk through one end of it, that thereby it may be pull'd out at pleasure, crush it a little between the fingers and having anointed it all over with the Oyl of Bitter (or in want of that Sweet) Almonds, put it into the Cavity of the Patients Ear at Bedtime, and draw it out the next Morning, stopping the Ear afterwards with Black Wool, but if need require this Operation is to be reiterated with fresh Garlick for some days successively.

Garlic-bulbs seem to have borne the divine inscription of suppositories, for they were freely recommended for all the cavities so medicated.

It seems unfair to quote so much from the unofficial exponents of the healing art, but some of their recipes were so titillating that it would be a shame to pass them by. ''Against the colic,'' medicaster Porta writes:

> Civet is most excellent in this disease: for the quantity of a Pease applied to the Navil, and a hot Loaf out of the Oven clapt over it, presently easeth the Pain: the Patient must ly on his Belly upon the Bread before it is cold.

The Virtues of Tobacco

Tobacco had been introduced into England from America about the beginning of the seventeenth century and, though it had been the subject in interdictions both sacred and profane, its medicinal use must have been sanctioned by special dispensation, for by the middle of the century it had been learned that,

> Out of the seed of it is expressed an oyl . . . , which allays the cruel tortures of the gout; the juice clarified and boiled into a syrup and taken in the morning, maketh the voyce tunable, clear and loud; very convenient for singing Masters. If you bruise the leaves and extract the juice it killeth the lice on childrens heads, being rubbed thereon, the leaves cure rotten Soars and Ulcers, running on the legs, being applied unto them.

In this connection it may be well to sound a warning against the indiscriminate use of the ''oyl of tobacco,'' for the Royal Society, in its early days, found by experiment that one drop of it was fully as efficient as curiosity in killing a cat.

The discovery of new virtues of this versatile weed seems to have continued, for an early nineteenth century pharmacopoeia lists a tobacco enema. About the same time the surgeon and anatomist, Sir Ashley Cooper, recommended this in a heroic dose as a preliminary to reducing difficult hernias, because it caused such extreme languor that the patient had ''not the power to exert any of the voluntary muscles of the body,'' thus, almost repeating the Royal Society's classic experiment on the cat.

Cosmetic Medicine

Most medical works of the Dark Era contain a section headed *''De Decoratione''* or something similar. From the beginning of the seventeenth century a great part of this fertile field seems to have been alienated from the medical realm. The cosmetic methods employed are often very amusing. In the third book of the *Brevarium Practicae,* Arnold de Villanova (1235–1320) says, ''In this book I intended, God being my helper, to treat of the sicknesses which especially concern women, and as women are in general venomous animals I shall follow it up with a treatise on the bites of venomous animals.'' But though he thinks them venomous, he at least would like to have them comely, and he, accordingly, interjects a long chapter on female adornments. A large portion of the advice offered in material of this sort treats of dyeing the hair of the scalp, eyebrows and eyelashes, making it grow or removing it, painting the face, removing wrinkles from various parts and all the other alterations in which the present era is so proficient.

Involuntary epilation appears to have been a problem from the earliest times, and remedial prescriptions seem to have been as numerous throughout the ages

as they are to-day. A very highly recommended medicament directed at this distressing state comes from the Gaelic:

> With mice fill an earthen pipkin, stop the mouth with a lump of clay and bury it beside a fire, but so as the fire's too great heat touch it not. So let it be then for a year, and at the year's end take out whatever may be found therein. But it is urgent that he who shall lift it have a glove on his hand lest at his fingers' ends the hair come sprouting forth.

Almost as numerous as the methods for growing hair are those designed to remove it. One given by the somewhat occult but encyclopaedic Giovanni Baptista Porta in his *Magia Naturalis* (English Translation, 1658) directs that one,

> First foment the part with hot water, and pull out the hairs one by one with women's nippers: then dissolve Salt Peter in water, and anoynt the holes where the hair grew. It will be better done with oyl of Brimstone or of Vitriol [sulphuric acid]; and so they will never grow again; or if they do after a year, they will be very soft: do then the same again and the parts will be bare always.

"So," the author asserts, "I have made many a womans forehead longer, and have taken off hair from parts hotter than the rest."

The same author offers a timely solution as to how a "woman deflowered [is] made a virgin again."

Absent Treatment

Absent treatments were perhaps as popular three or four centuries ago as they are to-day. Paracelsus was a great advocate, if not the author, of one of these, for healing wounds. The application was, curiously, not to the injured part but to the object responsible for the damage. This was the notorious "weapon salve." It was supposed to operate through the mediation of magnetic rays passing from the weapon to the wound. The ointment was prepared as follows:

> Take of the moss growing upon a dead man his skull, which hath laid unburied, two ounces, as much of the fat of man, half an ounce of Mummy, and man his blood; of linseed oyl, turpentine and bole-armick [Armenian clay] an ounce: bray them all together in a mortar, and keep them in a long straight glass. Dip the Weapon in the oyntment and so leave it.

Further directions were:

> Let the Patient in the morning wash the wound with his own water; and without anything else tye it up close and he shall be cured without pain.

Perhaps this was better treatment than many others current at that time, for even taking into account the morning ablution, the method at least tended to keep the wound from much additional contamination, which many of the others did not. Besides the here-mentioned use, briny effluvia of this nature had a variety of others, among which were to relieve dyspepsia and constipation and as a lotion for the skin. Curiously, a variety of skin disorders are still popularly treated in this fashion. Preparations from dead men's skulls were even more highly esteemed. Their special domain was in disorders of the brain. Just before muttering his dying wish, "Don't let poor Nelly starve," Charles II drank a jigger of one of these preparations.

Sympathetic Remedies

An equally irrational type of treatment was the "sympathetic powder" of Sir Kenelm Digby, an English physician and courtier of the time of Charles II. This nigh omnipotent powder was nothing more than green vitriol or iron sulfate. "The rays of the sun," Digby explained, "extracted from the blood and vitriol associated with it, the spirit of each in minute atoms. These combined in the air, and the air charged with the atoms of blood and vitriol, were attracted to the wound and effected the cure." The famous chemist and physician, van Helmont, who first produced coal gas, was one of Sir Kenelm's col-

laborators in the writing of a book on this brand of treatment. Van Helmont had at one time been almost killed by a very unsympathetic cathartic prescribed for the itch, and that fact may have had something to do with his alliance with Digby and his "sympathetic" medicines.

Sir Kenelm gives one for whooping cough, in which the patient's nails are to be pared and the parings enclosed in a little bag, the bag to be hung about the neck of a live eel and the eel to be placed into a tub of water. "The eel," he assures, "will die, The patient will recover." Whether the cause of death in the eel will be whooping cough or strangulation he leaves unmentioned.

What corruption was sometimes considered necessary to combat corruption, under this "systematic" system, is seen from van Helmont's prophylactic against the plague.

> Large old frogs caught in the month of June and hung up by their hind legs over a dish covered with wax which has been placed over a moderate fire. After a few days the frogs discharge terrible fumes and slaver which attracts every kind of worms and flies. These stick to the wax and add their own drivel to the mess. When the frogs are dead, roast and mix them with the carefully preserved wax and drivel and shape this compound into small rolls, or imitate the shape of frogs. One of these is sewn into a cloth and worn in the region of the heart suspended by a silk thread around the neck.

According to the author, this was such a remarkable remedy that before the publication of his book it had "gained such a reputation throughout the country that all 'barbers and blear-eyed witches' are already acquainted with its virtues."

Conclusion

It is a far cry from the optimistic credulity of that day to the sceptical science of ours. The hit-or-miss symptomatic dosage of former times has gradually given way to a rational therapeusis, directed at the cause rather than the effects of disease. Such treatment rests on a sound knowledge of the pathology concerned and the agents of causation. In the seventeenth century such knowledge was almost nil and even at present is very defective. In all justice to the healing art of bygone days, it must, however, be admitted that the treatment of not a few diseases is not much better now than it was then, and everything considered some of the cures were truly remarkable. Judging only from the remedies quoted in this article, this statement, of course, would fall somewhat short of substantiation, for only the most ludicrous therapy has been considered. If a man irrigates his eyes with boric acid solution it is not news, but if he employs Boyle's dusting powder it is.

TERRITORIAL EXPANSION

A STUDY IN POLITICAL GEOGRAPHY

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THE significance of political geography has been recognized by a number of American geographers; for example, Bowman devotes much attention to it in "The New World," as does Semple in "Influences of the Geographic Environment," and Brigham in a number of writings. Moreover, two chapters are devoted to it in the widely used college text-book, "Principles of Human Geography," by Huntington and Cushing. Nevertheless, it has not received the attention in American universities that it merits. Tower, to be sure, gave a course in political geography at Chicago from 1912 to 1915, and Whittlesey one there for some years later. During recent years, Hartshorne has given a course at Minnesota, and Whittlesey intends to introduce political geography soon at Harvard, and Van Valkenburg at Clark. Apparently, therefore, the complications and uncertainties introduced by the world war, the growth in interest in regional and economic geography and the strong movement towards the factual, descriptive geography merely have postponed the adequate exposition of political geography in American universities.

The following generalizations as to territorial expansion are offered in the hope that such hypotheses as these will stimulate thought, increase observation and lead to the gathering of more facts in this socially significant division of geography.

I. COUNTRIES TEND TO INCLUDE SOME SEACOAST

Nearly all the countries of the world border the sea. The exceptions are Bolivia and Paraguay in South America, Ethiopia (Abyssinia) in Africa, Afghanistan, Bhutan and Nepal in Asia, and Switzerland, Czechoslovakia, Austria, Hungary and the tiny, mostly mountain, states of Andorra, Liechtenstein, San Marino and Luxembourg in Europe. Of these fourteen, only the four larger central European countries are commonly considered of world significance, and only Switzerland of these four antedates the world war as a country lacking coasts. This coastal distribution of countries is largely a result of the facts that (a) those countries which started in the interior, and have survived have nearly all expanded until the coast was reached. (b) Many additional countries started as coastal colonies. Both of these statements are true largely because the sea is the world's great highway. As commerce upon the sea has increased, so had the desire to reach the coast, despite the fact that since railroads have become available the sea is no longer nearly so overwhelmingly important as a commercial highway as it formerly was.

The fact that the sea is the source of a significant amount of fish and other sea products increases the desire for ready contact with it. Sea food was formerly so much more significant than it is now that it is hard for us beef, wheat, sugar and fruit eaters of to-day to realize how important fish formerly were in the diet.

A third reason for the desire of statesmen that their country reach the sea was that it was considered to be the most satisfactory boundary to a realm. It was thought of as definite, and suffi-

ciently isolating so that there would usually be far less trouble in respect to the entrance of armies, or of expanding peoples, than there would be along most other boundaries. From the standpoint of tariff levying, the coast was considered to be a desirable boundary also, because goods which enter a country and are subject to a tariff tax can enter at fewer points, normally, than across most other kinds of boundaries.

It is now generally considered so desirable that a country extend to the sea that Poland was given a "corridor" to the Gulf of Danzig, despite the fact that this separates East Prussia from the rest of Germany, and introduces several annoying complications. In other instances the League of Nations has augmented the internationalization of certain rivers—for example, the Danube and the Rhine—to permit the commerce of inland countries to reach the sea more readily. Certain ports in other countries are also directed by the League to be made available to the use of certain inland countries. For example, Fiume, in northeastern Italy, and Susak in Yugoslavia may be readily used by Austria and Hungary.

The expansion of inland political centers to the coast has been aided by the fact that, if the area below is not strongly occupied by an unfriendly people, it is easier to trade and expand down a valley than up one. The extent of coast held by a country depends, therefore, partly upon the distribution of rivers leading to the coast.

In the past, when river commerce was highly important, it was considered especially desirable to control the mouth of the river. For example, one of the advantages of the Louisiana Purchase stressed at the time was that as a result of that purchase the United States controlled the mouth of the Mississippi River, then considered to be the chief outlet for the future exports of the midwest.

The seacoast is more important now as an international boundary than it was 400 years ago, before the sea was much used as a highway, and when each locality was largely self-sufficient. Then most of the numerous principalities were interior lands, and some of the strongest—for example, Austria, Bavaria, Burgundy and Russia—did not reach the coast.

II. Superior Seaports Tend to Be Incorporated into the Stronger Country Nearby If Situated So As to Serve It Advantageously

Not only do nearly all countries reach the coast, but there is a strong desire for superior seaports, for only by means of ports is an effective contact made with the sea. A good harbor, if well situated, may indeed, have naval or even commercial value although it has only a poor hinterland. Conversely, a poor harbor may become a significant port, provided there is no better harbor available to serve a rich hinterland, as is proven by the fact that some of the chief ports have harbors that are largely artificial. But what is most desired, of course, is the combination of a good harbor and easy access to the hinterland.

Numerous countries have illustrated the principle that strong countries tend to expand so as to obtain the best ports readily available. Russia's expansion before 1914 was much influenced by the desire of her leaders for a good ice-free harbor. America's boundary at the extreme southwest was placed far enough south so as to include San Diego, with the best natural harbor within a long distance. The Virgin Islands were purchased largely to obtain the harbor of St. Thomas, considered especially desirable as a base for naval operations in

the defense of the eastern approach to the Panama Canal. Italy's recent expansion eastward to include Trieste and Fiume was influenced by the fact that these ports are far better than others in northeastern Italy. This expansion took place almost as soon, as these, as the result of the dismemberment of Austria-Hungary, were in Yugoslavia, a less advanced country industrially and commercially than Italy.

The tendency for the stronger country to include good ports has been so great as to justify the generalization that, in the past, where a superior harbor or port was situated near the boundary between two countries of unequal strength it generally was incorporated within the stronger of the two countries; if not originally, then eventually, provided it could advantageously serve the stronger country.

III. Active Countries Tend to Expand into the Sea to Include Nearby Islands and Sometimes Coastal Areas Opposite

A third great generalization as to territorial growth is that the stronger countries expand to include nearby islands. So many islands have been annexed by nearby mainland countries that it is hardly worthwhile to cite examples.

The geographic bases of this annexing of islands are (a) the interest of the people of the continental area in the fish of the sea, and in the islands as a base for fishing, drying the fish and trade. (b) The further fact that island peoples, with few exceptions, have less diverse and abundant resources and fewer means of making a livelihood than are present in most neighboring continental areas is also of importance. As a result of a restricted environment, the people of islands generally lead a relatively simple life, and are less prepared to meet unusual conditions than are the people in continental areas. Biologically also, island peoples and the lower animals and the plants as well are, with few exceptions, less diverse and resourceful or capable of extensive adaptation than are those of continents. Hence, when competition occurs, the insular forms usually lose out in the struggle. The chief exception to this latter rule is afforded by especially favored islands, such as Great Britain and Honshu. Although both of these were conquered by peoples from the mainland, these islands, because of a fortunate combination of conditions, not only later became independent but expanded and incorporated smaller islands nearby, and also more distant islands and lands across the sea. Japan's annexation of Formosa and Korea are examples, as are Britain's annexation of the Isle of Man, the Channel Islands, Ireland, and for a long time parts of western France. But Great Britain and Honshu are clearly continental in resources rather than typically insular.

This tendency for strong countries to expand into neighboring seas has led several to expand across such seas and to include areas on the opposite side which are geographically less well endowed. Illustrations are the French, Italian and Spanish expansion into North Africa, the fact that Sweden long included Finland, and Denmark long controlled Norway.

IV. A Natural Geographic Unit Tends to Become a Political Unit

There is a strong tendency for a natural geographic unit such as an island, a peninsula, a plain set off by mountains and the sea, or an area of similar climate, to become a political unit. The rapidity of consolidation depends partly upon the comparative strength of the peoples and leadership within the area,

and partly with its geographic distinctness. For example, different parts of the island of Great Britain were for a long time held by various almost equally strong peoples and political units, with a result that centuries were required for it to become politically united. On the other hand, there was such a disparity in strength between the English-speaking people and the aborigines there that "temperate North America" was nearly all united comparatively promptly. The exception is the southern section of Canada, that belongs in this large geographic unit but which formerly contained a predominance of French-speaking people. Australia affords an even better illustration, as no part is excepted. Another excellent example is Russia, which started in the western part of the world's most vast plain and expanded until almost all the plain was annexed. Towards the east, northeast and southeast, expansion was easy, as in those directions the Russians encountered less energetic, less well-organized and less advanced peoples. Towards the west, however, they met stronger peoples and made little progress. Indeed, since 1917 Russia has lost nearly all the territory in that direction which had been previously laboriously won. Likewise the consolidation of the rather distinct geographic region of France into one country required centuries to consummate, partly because at the northeast there is no distinct natural boundary, and the people involved were highly energetic. There has been more fighting in that section to gain or to hold a comparatively few thousand square miles than were required to incorporate most of the rest of France.

Regions that are set off geographically have tended to become politically consolidated in response to three main influences. (a) Such regions, being rather homogeneous geographically, tend to become relatively homogeneous in respect to population, language, economic conditions and social ideals, as a result of an intermingling of peoples. This approach to human unity makes powerfully for political unity. (b) Another great unifying force is the fact that geographically distinct regions necessarily are set off from other regions by barriers of some sort; the sea; rugged zones, such as a mountain range, or belts that are unfavorable to close habitation because of aridity, marshiness or poor soil conditions. Such surrounding scantily peopled zones increase the tendency for the people in the better settled area to unite politically by increasing their bond of kinship racially and socially. In the isolating zones there are either no people, as on the sea or in lofty mountains, or else very few and mostly rather poor people, as in rugged, dry, marshy, rocky or sandy zones. Such people are likely to be sufficiently different culturally from the people of the more densely peopled area so that they are bound to them culturally by only relatively weak bonds. The tendency for a country to expand to reach the sea, mentioned earlier, is another influence leading to the consolidation of natural geographic units. The tendency to expand to reach the other sorts of isolating barriers is less strong and usually slower and less intentional than is the expansion toward the sea. Much of it comes about as a result of the slow spread of people and culture out from the richer parts of the natural region. However, the fact that mountains commonly have been considered to afford protective boundaries because of the difficulty with which they formerly were crossed, has had a considerable effect in encouraging expansion to the mountain barrier, if one is convenient.

(c) A major reason why there are so

many countries in Europe is because there are so many rather distinct geographic units in western and southern Europe, each of which has tended, in keeping with this principle, to become a separate country. The eastern part of Europe with its vast plain contains chiefly only one country, while the remainder of Europe with its many islands, peninsulas and other areas, somewhat set off by mountains or sea, contains many countries. Because of the historical significance of the numerous political entities of Europe it will be worthwhile to briefly sketch the situation in Europe from this point of view.

European islands containing independent, semi-independent or formerly independent countries are Great Britain, Ireland, Iceland, Crete, Corsica, Sardinia and Sicily. Peninsulas occupied by independent nations or two or more countries are Jutland, Italy, Greece, Scandinavia, Iberia and the Balkan Peninsula. Two others, Crimea and Brittany, formerly contained distinct political units.

The sea has been of significance in setting off certain European countries, in addition to the islands and peninsulas already mentioned. For example, the essentially coastal countries of Finland and Estonia are separated by the Gulf of Finland, and Estonia and Lithuania are partly divided by the Gulf of Riga. East Prussia, also primarily coastal, is separated from Poland partly by the Gulf of Danzig.

The mountain ranges of Europe have also played a part in increasing the number of political units. Since the eleventh century the Pyrenees have generally served as a political boundary; Italy and its predecessors, if the rather loose Holy Roman Empire be excepted, have seldom extended beyond the Alps, nor has modern Germany or France. The Kjolen Range helps separate Norway and Sweden; and the Karpathian Mountains, with their southern extension, the Transylvanian Alps, have repeatedly served as political boundaries. Similarly, Bohemia, surrounded on three sides by low ranges, has had a considerable degree of economic independence and political individuality. Mountain ranges have also been significant in delimiting countries in the Balkan Peninsula.

Other sections of Europe are set off in part by other types of physical features. For example, a marsh has partly separated the Netherlands from Germany throughout the last 400 years. Marshes formed parts of the boundaries of several German states that were independent before 1871, and the extensive Pinsk Marsh helps separate Russia and Poland. Lakes have played a rôle, too, though a minor one. For example, the eastern boundary of Estonia is mostly formed by Lake Peipus, the southeastern boundary of Finland by Lake Ladoga, and parts of the boundary of Switzerland by Lake Geneva and Bodensee (Constance).

With physical features tending to divide Europe into so many separate units, it has been only since facilities for transportation and communication have become generally efficient that the influences tending to unite western Europe politically have been at all strong in comparison with the influences tending to divide it into many units. Even the "Pan-Europe" dream does not include Britain, set off by the sea, or Russia, which because of its vast territory in, and wide contact with, Asia is often thought of by Western Europeans as semi-Asiatic rather than as European. However, from the viewpoint of the world as a whole, Western Europe of to-day comprises, as a result of efficient transportation and communication, a single geographic unit, more

distinct geographically than is "Temperate North America" or Chile; and hence, according to the principle of political geography under discussion, it presumably will ultimately function as a unit in many respects. Because of the human barriers imposed by differences in language, laws and the tariff, it appears, however, that any considerable amount of unification must await a considerable increase in commercial and cultural exchange.

The tendency for a climatic region to consolidate politically was illustrated by the Roman Empire, which was essentially the Old World region possessing a Mediterranean type of climate. It only extended widely beyond this limit for comparatively short times, and incorporated regions in diverse climatic types far less completely than it did regions with the Mediterranean climate. Similarly, the Islamic World has been essentially the Old World desert and its borders. Russia, too, nearly all possesses the continental type of climate. Since 1917 the parts of the former realm that were less intensely continental, the western zone bordering the Baltic and south from there, seceded. These areas had not become an integral part of Russia partly because the climatic conditions were sufficiently different from those of most of Russia so that the manner of living was different. The United States is likewise nearly all of one major climatic type, the continental, despite the inclusion of narrow strips of the Mediterranean, marine and semitropical climates.

Northwestern Europe is climatically decidedly homogeneous, of the marine type, but the southern part of Western Europe is of a different climatic type, the Mediterranean. What part of the failure of the people of the three great climatic regions of Europe, the marine, the Mediterranean and the continental, to understand each other is due to the differences in climate it is impossible to say, but doubtless a considerable share. The fact that most of the people of the continental climatic type are of the Slavic subrace, while those of the marine climate are largely dominated by the Nordic subrace, and the Mediterranean by the subrace so named suggests the fundamental importance of the climate. These climatic and racial differences supplement the physical features in retarding the unification of Europe.

V. Areas Having Similar Cultures Tend to Unite Politically

Not only does a natural geographic region tend to unite politically, but where the culture of that natural region has extended beyond it, such outside areas also are likely to come to be united politically to the cultural homeland. Since one of the conspicuous and most significant elements of advanced cultures is the written language, this generalization is illustrated by the uniting of peoples using the same language. Modern Germany not only includes many formerly independent principalities in the North European plain, but also various formerly independent principalities somewhat isolated by mountains. The fears of leaders in other countries have been the chief influence recently to prevent the uniting of postwar Austria, with its predominantly German language and culture, with Germany. Likewise, modern Italy includes not only the natural geographic unit but also various nearby areas containing many people who consider themselves Italians.

This principle is well recognized in international law, where it is held that the best claim to sovereignty over an area is its permanent occupation by nationals of the claiming country and

their descendants, and the maintenance of contacts between the two. Neither discovery nor a formal declaration of annexation are comparable in validity in international law to this cultural bond.

VI. Geographically Favored Regions Tend to Become Strong Countries

The generalization that a natural geographic unit tends to consolidate politically and belong to one country leads to the development of countries of diverse size and natural wealth, because the natural geographic regions differ widely in these respects. Where the natural unit is poorly endowed, only a weak country can result, so long as it is confined commercially and otherwise to that unit. Conversely, where the natural unit is well endowed, the resulting country readily becomes strong. The strength of France as compared with Spain, of Germany as compared with Hungary and of Italy as compared with Greece are illustrations of this rule.

As the resources of any region are at first not effectively used, a country may grow in comparative strength while its resources are being developed, or it may decline as compared with other countries, because its rivals are developing resources which they formerly did not use. For example, when agricultural wealth was of preeminent importance, France had a greater advantage over Germany than when minerals became highly useful, for Germany has much more coal and potash than France. Furthermore, Germany used her remarkable potash deposits to overcome part of her handicap of poorer soils. Similarly, now that Norway's water power is coming to have value, Denmark no longer has such a great advantage as formerly, when it had no value and agriculture was predominant, when for centuries Denmark dominated Norway politically. So too, Switzerland is comparatively far better off now, when its water power can be used advantageously, and when many tourists come to enjoy its scenery and climate, than it was when the higher sections of the country and the steeper slopes had almost no value.

Consequently, the strength of a given area varies from time to time with the advancement of civilization and the market for its resources; but, nevertheless, the geography of the area determines to a large extent its comparative wealth and has a great deal to do with the strength of the country occupying it.

VII. Weaker Countries May Be Annexed to Stronger Ones, Not the Reverse

A comparatively strong natural geographic unit, after it has been consolidated into a country, tends to expand so as permanently to include weaker units adjacent or convenient. This has often been noticed, but the reasons for it are often overlooked, as is the fact that history affords practically no examples of the reverse taking place, geographically poorer countries annexing richer ones, despite the aggressiveness of some leaders of poorly endowed countries. Three reasons why it is always the stronger country geographically that expands, and not the one that is stronger in its military organization or in the ambition of its leaders, are:

(1) Annexation requires more than temporary conquest. Although the people from a weaker area may be physically strong and daring, and under primitive conditions sometimes better fighters, they lack the cultural strength which predominant numbers give. Hence, they relatively soon have lost control. Under modern conditions, even war, with all its barbarism, requires so

much scientific knowledge, systematic cooperation and utilization of resources, that a geographically weak country, with its lesser resources, small population of advanced individuals and its handicaps to cooperation, is at a very distinct disadvantage and has small prospect of winning a war against a more favored country, and, as already remarked, even less chance of retaining its conquests if, because of superior leadership, it should win. Paraguay affords a good illustration. Under Roca, conceded to have been a military genius, Paraguay waged war against Brazil and Argentina. But, despite Roca's predominant skill, the stronger countries won.

(2) Another reason why the stronger country expands is due to the fact that the limited resources of the poorer area can be more advantageously used in the richer one with its more diversified activities, larger population, better contacts with the outer world and greater capital. As a result of this, there commonly is a considerable development of the resources of the poorer area after annexation and increased prosperity in both. If the poorer area annexed the richer one, the lack of experience and capital of the leaders in the poorer area would cause a decline in the richer area.

(3) Moreover, the market for the exports of the weaker area is normally in the adjacent stronger area, and as annexation facilitates the exchange of goods, it is often desired by the weaker area, whereas richer areas would not gain by being under the control of a weaker one. An example of the desire of weaker areas to be annexed to stronger ones is afforded by the Hawaiian Islands, which applied for annexation to the United States chiefly because such annexation would be advantageous to them, as after annexation there was no tariff barrier against their sugar and pineapples.

An understanding of this rule that stronger areas annex weaker ones and never the reverse will have in general a desirable effect by reducing ungrounded fears, for example, that countries that are, in fact, decidedly the weaker geographically could possibly conquer far stronger ones. The reduction of such fears will make for disarmament and for international peace.

The tendency for the geographically favored countries to annex less favored areas does not imply, therefore, that these weaker areas are necessarily forced into the union or are in any way harmed by it. Indeed, if it were not for the fears of influential persons in other countries, doubtless several geographically weaker countries would promptly unite with stronger ones. A recent case is Austria's desire to join pre-Nazi Germany, and Luxembourg's overwhelming vote to join France, which country refused, however, and hence Luxembourg attached itself to Belgium.

Economic considerations encourage annexations, or at least close cooperations, and economic influences are likely to gain in strength with increased international trade and with the decline of the spirit of nationalism, which decline is a logical result thereof. The League of Nations and the proposed "Pan-Europe" are results of this tendency.

An influence working against territorial growth of the strong countries is the fact that areas that are geographically poor often are a financial burden to the annexing country. For example, most of the French possessions are a fiscal liability, even ignoring their influence in increasing the expense of the military machine of France. The Philippine Islands are a heavy drain upon the American treasury when the effect of their possession upon the cost of the navy is considered.

The expansion of the richer countries is stimulated, however, by the spirit of

nationalism. Nationalists take pride in having the additional area and population and in wide-spread colonies. As the spirit of nationalism weakens, with the growth of international contacts, various "possessions" will presumably either be set free or else incorporated with other units which are in position to serve them at a lesser cost. The mandating of German Southwest Africa to the Union of South Africa, instead of its control from London, is an example of this logical trend, as is the almost complete independence of Australia, which now even has a navy for its own protection and was given a mandate over former German possessions not far away.

VIII. The Number of Independent Political Units Tends to Decrease

There are to-day only a fraction as many independent political entities as there were a century or two ago. The creation of several new European countries as a result of the world war and the arrival of a number of the British dominions to the status of "Members of the League of Nations" might be interpreted as an indication that the tendency towards consolidation has run its course. But the characterization "independent" in the generalization has especial significance. Many of the so-called independent countries of to-day are, in fact, not independent, and even the most powerful are surrendering voluntarily more and more of their independence in respect to international affairs, and even in respect to many internal affairs. They are binding themselves increasingly to observe various international agreements and are submitting more and more to various international tribunals. In doing this they profit in many ways, but at a loss of a considerable degree of independence.

IX. The More Favored Regions Geographically Tend to Influence Increasingly the Less Favored

Whereas formerly most people were little influenced by those of other regions, because each locality lived largely unto itself, the situation has changed as a result of the tremendous growth of commerce and the spread of culture. It is trite to say that the world is all bound together, but it is not adequately realized that nearly all this uniting influence comes from the people in or from the geographically most favored areas, which have come to have an augmented advantage in many respects over the people in the less favored areas and to influence them more and more. In other words, European or Western civilization has spread, and is spreading to-day probably more rapidly than ever before. The political domination of Europe over the other parts of the world is at present almost complete, except so far as it has been tempered by a relegation of authority, including the granting of independence or semi-independence to regions which are dominated by European ideals if not by European individuals.

Americans may feel that America is an exception to this rule, but if they do so, this attitude illustrates their failure to realize that America is, in fact, largely an offshoot of Western Europe, and enormously influenced by it.

This augmenting dominance of the especially favored areas results inevitably from the increasing demands made by rising standards of living accompanying higher civilization with all that these higher standards imply. The less favored regions simply can not supply the material or cultural demands made by the awakening people of those less favored areas. Hence, they tend voluntarily to submit themselves to the eco-

nomic and political domination of the people in the more favored areas who can supply a larger share of the desired goods, capital and culture.

X. Political Control is of Increasing Significance

Another great trend is that governments have become increasingly significant. Before the modern era most communities lived so largely a local existence that it perhaps made little difference in what country it was situated. With the introduction of improved transportation and communication the situation has changed, however, and now the influence of the government is strongly felt in every part of all the more advanced countries, and it may make a great deal of difference to a community which country it is within.

However, if tariffs are reduced to the extent that many economists think rational, if expenditures for military purposes are greatly reduced and if all well-peopled regions are served well by transportation facilities, medical science and other cultural forces, then it will again matter less to which country an area belongs. In the distant future the world may conceivably be divided politically into almost as many states as there are areas having people significantly different in race or special interests. These various states will presumably resemble the American states, however, in that their independence will be strictly limited, and also in the fact that from some central agency, funds and leadership obtained from the richer areas will aid in the utilization of the natural and human resources of the less favored areas. Only by such outflow from the geographically favored areas can the poorer ones continue to be highly civilized and enabled to make their own contributions to civilization. Although these outflows of capital and skill must be greater from many areas than can be compensated for permanently in kind by the less favored areas, there are other sorts of return. The Philippine Islands, for example, have been worth much in the education of the American people.

SCIENCE AND THE LAYMAN

By Dr. BENJAMIN C. GRUENBERG
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PEOPLE go to the library for books, they buy magazines, they write to the editor, they consult an expert, they discuss with their neighbors. They do one or several or all of these things in order to get information that will enable them more satisfactorily to operate their radio or motor boat, to mix and apply paint or concrete, to bait a hook, to redecorate their homes, to improve their golf or card game. All this is adult education. And some of it has to do with science.

The most widely felt needs for scientific information or guidance are related to technological applications. These needs manifest themselves in mechanics institutes and in agricultural extension courses. There is a constant demand for instruction in the better care and feeding of children. Thousands of books and pamphlets are used up to enlighten folks on the workings and management of internal combustion engines and chicken farms.

Various studies indicate that over a long period there has been a trend toward greater interest in science on the part of the general adult public. Parallel to the increase in high-school and college enrolments, since the beginning of the century, there has been a marked relative increase in the circulation of popular science magazines, as also in the number of science articles in the general magazines. There has also been a very striking increase in the amount of space given to science topics in the newspapers, especially during the past ten years. On the other hand, the organized instruction of adults in the natural sciences does not seem to keep pace with the amount of instruction in these fields offered in high schools and colleges. Whereas the schools have been giving about 10 per cent. of the students' time to the sciences, and the colleges about 15 per cent., the extension classes and other voluntary study groups for adults offer science to approximately 4 to 6 per cent. In England also, and in other European countries for which information is at hand, about 5 or 6 per cent. of the adult educational activities are in the sciences. Half a century ago, some 50 per cent. of the university extension courses of the English universities were in the sciences.

This marked decline in science classes for adults has caused serious concern, if not alarm, on the part of educators, sociologists, philosophers and publicists, as well as among leading scientists. Similar concern has manifested itself in England, where a committee of the British Association for the Advancement of Science reported on the problem at the Leicester meeting last September (1933). This solicitude has been justified in various ways; but, with the exception of some five or six out of about 200, all scientists and educators interviewed in the course of a study made in the winter of 1933–34 agreed substantially that there is a real need for the wider diffusion of scientific knowledge and scientific attitudes among the population at large.

Living in an age that is being modified by science calls for an education which equips one to meet a variety of changes. Unlike much of the traditional education, that which is now needed can not consist merely of accepted knowledge or of specific skills. Both what we know about the world and about ourselves and

the procedures by which the necessary work is carried on are being altered by the impact of science. It is impossible to foresee these changes in detail, and preparatory education involves therefore not so much definite beliefs and techniques as a certain attitude—a readiness to consider the new without prejudice and to reexamine what has been, a constant requestioning of old values, a retesting of old procedures.

Science as a method of dealing with ever new problems or with old problems in new settings must be democratized, must be removed from the exclusive custody of specialists, must be assimilated by the entire population and made part of the common life.

The decline of science in adult education, as indicated by the figures regarding classes and extension courses, may, however, be apparent only, not real. The expansion of the common schools to reach nearly the entire population and the extension of the high-school facilities until about half of the boys and girls of high-school age are actually enrolled have resulted in making the adult population increasingly able to rely upon the printed word for much of the information and enlightenment that in the past had to come by way of the living voice. If in some cases poor instruction has made some of the grown-up boys and girls indifferent to science or satisfied that they had finished the subject, in other cases the school instruction has made unnecessary adult classes in the elements of science. A parallel decline over a generation in the prominence of mechanics institutes or of night classes for teaching adults the art of reading may indicate not a loss, but a substantial gain, in cultural development.

When every person of voting age will have had the equivalent of an introductory course in general science during the regular schooling, there will be no occasion for adult classes in elementary science. Similarly, when the daily news brings reports of "findings" in terms that are generally intelligible and that for the time being satisfy the curiosities, there may be no more occasion for special classes in science for adults than there is now occasion for special classes in grammar and rhetoric for college graduates.

It is not to be assumed that such decline as has taken place is all accounted for or all compensated for by the changes in educational procedures and opportunities that have been suggested. There is indeed evidence that the situation has been affected by other factors. In many cases opportunities and facilities are inadequate for existing needs and demands. In other cases opportunities are withheld because those in charge of adult education programs themselves lack understanding and appreciation of science in modern life. Scientifically trained men and women are under such pressure to continue research or to teach in academic institutions that there is little encouragement for competent scientists to attend to work with adults. There is also the competitive demand upon the limited free time: the "hunger for recreation is far from satisfied." And there is further the competition of other educational or cultural interests. Increasingly since the world war, and especially during the past four or five years, the serious reflection and inquiry of adults are turning to questions of economics, social relations, political and international relations and practises. The controversies, which themselves stimulate interest in serious study, have less and less to do with reconciling science with various theologies, and more and more to do with reconciling science as embodied in the new technologies with various assumptions as to the good life in an industrial society.

One further change, which is itself the outcome of the diffusion and advancement of science, may have a bearing here. A generation ago the scientists

generally felt the evangelical urge to share with others the benefits that they had gained from preoccupation with scientific pursuits and reflection. While statesmen, whether benevolent or despotic, and reformers feel that people need to be educated, the scientist feels that his own findings and thinkings are important for all. It was during the second half of the past century that this spirit reached its widest expansion. Tyndall and Huxley in England and Haeckel on the continent were the very embodiments of this spirit. But one of the consequences of more study and reflection by scientists was the weakening of the evangelical urge. A philosophy that starts out with doubts and ends with tentative conclusions and that raises so many additional questions as it moves along can not address itself very convincingly to the promulgation of a new gospel. Thus it happens that while there is a tremendous increase in systematic propaganda of all sorts, and while the individual evangelist can still get public attention, the furthering of science by such methods has steadily declined. Moreover, the scientists as a group are no longer under the same compulsion to urge upon the public an appreciation of science, nor (until quite recently because of the identification of "unemployment" with excessive technological efficiency) do the scientists feel so much the need of defending science against general hostility. Science has indeed come to be taken for granted; the scientist feels relatively secure; and perhaps at the same time the public feels an unwarranted reliance upon some mystic capacity in "science" to solve all our problems.

The popularization of science in the past, and down to this very day, may conceivably operate to the injury of science. It is not merely, as some scientists seem to fear, that the oversimplification of the specialist's ideas makes the specialist out to be rather simple-minded or exposes him to foolish discussion by the ignorant. The danger lies in reducing science to a modern form of magic. Much of the popular science, in newspapers and in other media, is trivial and misleading. It arouses awe and admiration perhaps, but also credulity of the blindest sort. There is something of condescension in the extravagant emphasis upon the spectacular. Science has produced startling results by bringing about action through space. You can hear Byrd's voice in the comfort of your home while the explorer is buried in the snows thousands of miles away. You can spring the front door of your exposition open by a beam of light from the star Arcturus, which is even farther away. Science has enabled us to see right through the deceptions and illusions that unscrupulous mountebanks in the past imposed upon the gullible public. It exposed spiritual mediums and forged signatures and defective armor. And it is in turn able to perform miracles far more wonderful than any dreamt of in the past. It not only makes bread more abundant, at least on the average, but it supplies an interesting circus and reveals hidden mysteries.

Thus science has been "sold" to the multitudes, and the public has become favorably disposed toward science. But through the familiarizing of the public with the terms and symbols that suggest the marvelous, this public becomes conditioned to further exploitation of its residual ignorance: the way is paved for quacks and frauds who can reenforce their blandishments with the magic words supplied by science. The mere selling of science may thus become a disservice: familiarizing the public with new words may do more harm than good.

Through the zealous dissemination of such science we have all become familiar with vitamins and ultra-violet rays, with endocrines and hormones, with colloids and enzymes. To be sure, we do not always know what these things mean;

but we are nearly all confident that they imply something very profound and very important.

The newspaper and other popularizations supplement the news with advertising. The whole population becomes aware of the virtues of toasting for ice-cream or shaving cream: heads of great industries and great educational institutions applaud the initiative that calls upon science to toast its products with x-rays in a manner that makes everybody feel that he must have toasted lead-pencils. We absorb the gospel of stream-lined tooth-brushes and radio cabinets. When everything else fails, we are converted to the merits of wrapping each doughnut in its individual capsule of Cellophane.

Much of the popularization of science for adults is closely related to technical or vocational instruction. It informs the public of better ways of doing things. It is a manifestation of that phase of science which Francis Bacon glorified as giving man power. It represents usable knowledge. But in the process of diffusion, no distinction is made between useful tricks facilitating and enriching the routine of life and propaganda for the acceptance of a special doctrine or for the sale of surplus stocks of superfluities. The ordinary reader is unable to check what comes to him. He does not know whether it is the honest finding or thinking of disinterested scientists or a fragmentary and deliberately colored "truth" separated from its setting in order to produce a desired impression in accord with a sales policy or a partisan assault.

This distinction we recognize to be important when we discover ourselves to be the victims of misrepresentation, or when, with a safe perspective, we can see the process operating at a distance. We smile with complacent superiority when we read of some backward nation "using statistics as an instrument of state policy." But the statistics for which we ourselves reach out to serve our purposes do not carry on the surface any certification as to their authenticity or reliability; and certainly the "interpretations" that come with the statistics are not easily tested, even by very intelligent men and women. Almost any kinds of statistics can be had to order—to "prove" that prices are going up or down, that unemployment is increasing or decreasing, that there is or is not a "business cycle." It is no wonder that some at least are suspicious of statisticians. But in a similar way it is possible to put out "evidence" from the chemical laboratory or the engineering or psychological laboratory, and so to divert us into buying our foods or cosmetics and fabrics and cigarettes from one set of producers and purveyors rather than another, under the charm of "science says." By the judicious use of scientific jargon a whole city can be made to insist upon having the bread that comes in pink wrappers.

If science as a mode of dealing with certain kinds of problems is to be effectively assimilated, it would be necessary to supplement the journalistic functions of the newspapers and the popular lecture and the radio broadcast with forms of comment that will bring out the cultural and philosophical implications of the "news" in science, as distinguished from the economic and technical applications—and especially from the commercial and industrial misapplications.

Of course every informed person knows that advertising exploits our ignorance, our prejudices, our fears, our vanities, our ambitions, our anxieties, our solicitudes for those we love. What we do not all know is that we are similarly misled by what passes for honest-to-goodness news and reports of what the scientists are doing. This is not to say that we are being deliberately misinformed. It means only that with a progressive division of labor which has become accelerated in modern times

largely because of the very nature of science, it has become increasingly difficult for the layman to understand what the scientist is thinking, just as it has become increasingly difficult for the scientist to address himself intelligibly to the general public.

For this failure in mutual understanding no party is to blame. The nature of language, which is essential to man's intellectual growth, is itself a source of the difficulty. In fact, many intelligent, educated adults, who have not themselves given much attention to the study of scientific subjects, entertain a curious resentment against the science guild because the latter does not express itself in common language that ordinary folks can understand. In extreme cases there is a suspicion that scientists develop their own jargon simply to keep their secrets to themselves. We still find people who assume seriously and as a matter of course that physicians' prescriptions are written in Latin only to enable the druggist to charge an excessive price for something that could as well be bought for a few cents by giving the "common name." It is no doubt true that in many cases a common name could be used where a technical term is used, but, generally speaking, it is essential to the growth of science that new terms be invented and that familiar terms be restricted in their meaning for technical purposes. It is unfortunate that this irritates the layman, that it obstructs his approach to desired knowledge and understanding, that it tends to make the speech of the specialist mysterious and esoteric, and indeed often tempts the scientist to a certain pedantry and exclusiveness. It is not true, however, that "plain language" could be used just as well. Nor is it true that the specialized use of common terms can be avoided—except by the substitution of new technical terms which would be perhaps just as confusing. It is not necessary to defend the scientists for this elaboration of their own jargon. This process is absolutely essential to clear thinking at any level and in any field of human activity in which communication is required, in sports and commerce no less than in electrotechnics and metaphysics. Similarly, the arbitrary restriction of a familiar term to a specific meaning is to be found in the church and in the kitchen, in every area of occupation or organized relationships. In the very nursery "common" words are turned into pet names and restricted to familial functions.

The language of the specialists is thus of necessity a foreign language to the lay public. But as strange words become familiar, and especially as familiar words become embodied in this strange language, there is the constant danger of the reader or listener jumping to conclusions, drawing inferences, forming conceptions that are not within the intent of the speaker or writer. The progressive separation of the scientist's concerns and thoughts from those of the layman, coupled with the immediate relevance of many of the scientist's doings in our daily lives, has made it increasingly necessary to develop intermediaries who will translate the foreign language of the scientist, as nearly as may be, into our common language and thought.

It is not to be expected that the thought of the scientist can be converted into common thought; but certainly we must try to guard against the degradation of the common thought by divorcing it from science, the modern source of authority in so much of our common life. The diffusion of findings, the meanings, the methods of science can make valuable contributions to the individual's interests and concerns, as in improving his health and the management of his practical affairs or as in providing him with a healthful and satisfying and growing hobby. Science may advance the common cultural interests, as in

shifting authority from traditional beliefs and institutions to proven experts, or as in eliminating superstitions and fears, or in broadening the sympathies and tolerances of the members of a heterogeneous population. A general understanding and appreciation of scientific principles and methods may also advance the civic and social interests by directing more critical and independent thinking to the common problems.

Throughout the ages man has refused to accept the restrictions implied in his thin skin and tender muscles. He has been well called nature's recalcitrant son—a rebellious Lucifer, the beneficiary of Prometheus and his stolen flame. He has circumvented the orderly course of events that threatened to destroy him, by resorting to knowledge which strengthened his arms and lengthened his legs. We value science because it means power. It is the ultimate attainment of man in his struggle with the obscure forces of his environment, whether "natural" or "artificial," whether "material" or "spiritual." Science is the more or less systematic pursuit of knowledge which enables man to do as he has always done, only more so, whatever he wishes to do, more rapidly, more energetically. But with the gains come certain disadvantages.

For one thing, science eliminates individual differences. As Carlyle said of gunpowder, it makes all men of like stature. Pulling the trigger does not call for great physique. Increasingly the same degradation of superiority has followed in the wake of scientific advancement. If science enables a Hitler or a Roosevelt to be heard round the world, it enables also a Caspar Milquetoast to carry his whisper far beyond the reach of his voice. It enables ordinary eyes to see the moons of Jupiter or the granules in the tiniest microbes. Synthetic silk, Dean Ford reminds us, makes Judy O'Grady and the Colonel's lady sisters *over* the skin. By devising delicate gauges and automatic mechanisms man's ingenuity and science have enabled him to concentrate tremendous energies into a small area and to control that energy through trivial movements of levers and buttons—which a simple-minded child can manipulate as effectively as a wise and powerful giant. In these ways science has made us so much alike that for certain purposes we have lost our individualities: we have become numbers on the time-keeper's register, so many hands for industry, so many customers for commerce, so many heads per acre for the statistician.

But for another thing, science accentuates individual differences. If we can all see equally well the moons of Jupiter, the imagination of an Eddington or a Shapley can see what was far beyond Galilei or Kepler. If we can all see microbes in a high-school microscope, only a Pasteur or an Ehrlich can get new meanings out of what is now become universally patent. If everybody's voice can carry equally well around the world, he who has something important to say can now get attention as never before. The individuals of genius or creativeness have now greater opportunity than ever. Science enables them not only to magnify all man's doings; through it they have actually created what never was on land or sea. There are new colors and drugs, not to be found in a state of nature; there are new fabrics and plastics and alloys; there are new plants and animals such as the field taxonomist never saw. Through science we have accelerated all our processes. The evolution of species has been condensed into a lifetime. We can now ripen whiskey in a few hours and demolish a cathedral, yes, a whole city, in a few seconds.

Now everybody knows all this. Nobody can overlook the achievements of science in terms of total production or average output. This is not then in praise of science; nor yet in reproach. It is only in the way of emphasizing the

inherent danger of placing so powerful a weapon in the hands of immature, awkward, irresponsible men and women.

While science has filled man's surroundings with millions of exciting novelties, and has lengthened his span of years, it has also threatened to deplete his life of all meaning. The dissemination of science as "news" is on the increase, but the material offered the public is usually without any indication of its significance, as related either to the underlying problems and historical developments or to the interpretation of conditions and phenomena.

Some of the philosophical implications of scientific methods and specific findings have long been generally recognized. For example, there is little occasion today to dispute Galilei's removal of the earth from the center of the universe. Very few people who have had time to get their bearings are troubled by the doctrine that species are mutable, including the human species. The age of the earth is stubbornly restricted to some five thousand odd years only among the most benighted, as if it had any essential relation to religion or the conduct of life. More and more men and women are discovering the futility of disputing verifiable facts; and of speculating where facts are ascertainable. Opinion is being pushed off the throne of personal privilege. We are finding a new source of authority in the expert, and a new valuation of expertness.

The general tendency among those who have given some thought to the place of science in adult education is: (1) To value increasingly the hobby interest or the personal curiosity motive; (2) to demand more participation or activity on the part of the "learners," as against purely verbal instruction—telling or showing on the part of the teachers; (3) to lay more emphasis upon interpretational as against informational effort; (4) to attach increasing importance to cultural outlook and the development of appreciations and to systematic consideration of the social implications of the domination of science in our lives.

We are finding more and more appreciation of scientific procedure as a mode of looking at the problems with which life confronts us, a procedure that transcends in value the solution of industrial problems. But the scientists themselves are finding, often to their chagrin, that they have not consistently valued science outside their own fields. They have resembled other human beings in retaining infantile fantasies as to the good and true in many realms that had been overturned by other scientists. The distinguished chemist or physicist may still be found to speak solemnly on current problems—that is, other than chemical or physical problems—in the language and the concepts which he acquired in his undergraduate days. He relies as he did in his youth upon the authority of the great person—the statesman, perhaps, or the successful business man or the editor of his family's favorite newspaper—while he himself is constantly striving to overthrow authorities in the area of his own expertness.

There is reason to believe that large numbers of high-school and college graduates (including professionally trained men and women whose occupations rest upon the application of scientific principles) are quite as much in need of direct help and guidance in "keeping up with science," as are those who are admittedly without education in science. This problem is at any rate not restricted to the "under-privileged." Whatever value there may be in getting some people to acquire scientific attitudes and to master scientific methods of dealing with problems must be significant for all, within the limits of individual capacity. For keeping up with science means a great variety of activities. For the specialist, whether a professional or

an amateur, it is necessary to know what his fellow-specialists are doing. For the ordinary citizen it is not very important that a new kind of orchid or a new variety of flea has been discovered; or that an ancient species has been split up into three. It is not very important even that the atomic weight of one of the elements has been redetermined with the result of altering by two points the figure in the third decimal place. Increasingly science is important as it modifies our outlook or enriches our appreciations, whether of the things of nature or of the doings of man. There is as much thrill—for those who care for such things—in a neat demonstration or a refinement of deduction as there is in a fine piece of workmanship or in a beautiful design in painting or music, or a moving poem.

To know what problems preoccupy the scientist may be more significant than to know what he has found out. To get from the growth of science a more objective attitude toward those who are not altogether like ourselves may be worth more than being able to increase our exports and imports of material goods.

Finally, the concern of adults with science must lead to a new and searching consideration of the implications for social and political and economic life of the human process which we call science—a vast spiritual cooperation that is basically without guile or ulterior motive, that is for its devotees a truly religious experience, and that can continue only as thought everywhere is liberated—that is, as human beings everywhere convert the practical contributions of science into a means of material security in order to give the adventurous spirit of man broader scope and more substantial support.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE FORGOTTEN AGE OF CHILDHOOD

By Dr. P. H. FURFEY

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THE psychology of adolescence has long interested students of childhood. More recently there has been a great deal of excellent research on the infant and the preschool child. The intervening period, however, say, the period from about six to fourteen years, has even now been very inadequately studied. So little is known with scientific accuracy about this period that we may appropriately term it "the forgotten age of childhood."

It seems strange that this age period should have been neglected by scientists; for it is a time of important and dramatic changes. Between the ages of six and fourteen the child doubles his weight and increases about one third in height. Educationally, this period practically bridges the gap between the kindergarten and the senior high school. Socially, it extends from the dependency of the six-year-old to within a couple of years of the age when marriage and full-time employment are legal in some jurisdictions.

Perhaps the deepest significance of this age lies in this last fact of socialization. For it is here that the child learns the principles of that social cooperation upon which any successful democracy must be based. The six-year-old is an individualist. He has not learned to sacrifice his own individuality, except unwillingly, for the good of the group. But at fourteen the child knows that the success of the social whole may be more important than his own success. In more concrete terms, team games and club activities have become possible at age fourteen. They were impossible at age six.

Since this is true, we have good reason to be interested in this forgotten age of childhood. As educators, as parents, as socially-minded citizens, we have the task of training our children into a worthy citizenship. May I suggest that this task involves the forgotten age of childhood to a much greater extent than we have realized in the past?

To illustrate the progressive socialization of the child during the grammar-school age, I should like to tell you about some growth studies made by some of my graduate students and myself. We tried to get a series of cross sections of child life by studying boys and girls at the ages of six, eight, ten, twelve and fourteen. We interviewed each child within a few days of his birthday. We also used, as far as possible, mental tests, physical examinations, home visits and interviews with teachers and others who knew the child in question. The result was a series of case studies picturing child development at various stages throughout the grammar-school period.

One index of socialization is the gradual loss of shyness in dealing with adults. About one fifth of the six-year-old children were so shy that they refused to answer at all when addressed or else they answered in monosyllables or in a very low tone or even cried or ran away. At age fourteen, of course, shy-

ness of this extreme variety had disappeared entirely. Some of the girls particularly showed at this age an almost adult self-possession.

The growth of social control shows a similar rapid growth. Both the six-year-old and the fourteen-year-old yield obedience to the laws and customs of our civilized society, but the obedience is of a different sort. The six-year-old is likely to yield unquestioning obedience to any adult who speaks to him authoritatively. His life is regulated for him largely by the adults of his own household. At twelve, and particularly at fourteen, the child's obedience rests on a more rational basis. Before he obeys, he wants to know why he should obey. At this time also there is an increasing independence of home authority both in the case of boys and of girls. Companions of their own age assume a growing importance, and a new loyalty to these companions begins to modify the formerly almost complete dependence on home.

Not only is the child more dependent on his companions as he grows older, but the type of companionship changes. One very interesting index of this fact is the changing relation between the sexes. Of the boys studied at the age of six, 81 per cent. admitted that they played with girls. Six years later this proportion had sunk to the minimum of 20 per cent. At age fourteen it has begun to rise again with the approach of adolescence. There is, then, a sort of a neutral period in the midst of the grammar-school age when companionship between the sexes is very uncommon. Before this neutral period, the young children of both sexes play more or less indifferently with each other. After this neutral period adolescent boys and girls are beginning to adopt the adult relationship between the sexes. If we care to view the neutral period teleologically we may think of it as a period of preparation during which the sexes separate to prepare for the responsibilities of parenthood.

Play is another index of the progressive socialization which we have been discussing. Perhaps the most conspicuous feature of the play of the six-year-old is what is called "dramatic play," that is to say, play which contains an element of make-believe. At the age of six, 100 per cent. both of the boys and of the girls enjoyed dramatic play of some sort. For the most part this consisted in the imitation of some sort of adult activity. Most of these adult activities were those which the children had actually observed. Thus, for example, the girls played being mothers or teachers, while the boys imitated policemen, firemen or mechanics. Less common, and more characteristic of slightly older children, was the imitation of real activities which lay outside the child's actual range of observation. For example, boys imitated pirates, cowboys or Indians. Least common was dramatic play involving the imitation of imaginary beings, such as Santa Claus or of animals.

By the age of ten and twelve dramatic play had declined enormously in popularity. Certain special types, however, retained their hold upon the growing child. Boys continued to play with electric trains and with such construction sets as Meccano and Erector. Among the girls the two types of dramatic play which survived to this age were the making of dresses for dolls and dressing up in adults' clothing. For this latter activity a pair of high-heeled shoes seemed to be an absolute essential. With the aid of these and an old dress of their mother or elder sister, the girls enjoyed the temporary thrill of imagined adulthood.

Parallel with dramatic play but out-

lasting it chronologically was an interest in active, outdoor games. This interest showed itself at the younger ages in the form of rather unorganized free play. Thus the girls of this age enjoyed tag, roller skates, jump rope and similar activities, while the boys enjoyed rudimentary play with baseballs, footballs and basketballs, which, however, never took the form of the real team games of these names. The boys also skated on roller skates, played tag, ran, climbed and fought good-naturedly. By the age of ten the competitive element seemed to become more and more prominent in such activities.

Somewhere around ten or twelve a new type of play appeared and one of the very greatest importance for the social development of the child. I refer to the appearance of team games and club activities. This tendency is discoverable in both sexes but appears most strikingly in boys with their suddenly awakened enthusiasm for the standard team games—baseball, football, basketball, and the rest. The new interest in these games means something of tremendous social significance. It means that the boy has suddenly realized that the group may be more important than the individual. Hitherto his ambition has been bounded by the hope that he could himself do something striking and dramatic. He personally must be the center of attention. Now, however, he learns the new thrill of group success. He is content to play right field and enjoy a new sort of pleasure when his pitcher strikes out three men in a row.

The same changed psychology is shown by the new adaptability of both sexes to club life. The great national clubs, such as the Boy Scouts, the Girl Scouts, the Camp Fire Girls, appeal, at least in their junior programs, to children from the age of ten up. The sense of belonging, the thrill that comes from being a part of a social unity, makes this club life possible, where it was not possible a year or two earlier.

With the dawning of this social sense the child learns to be a leader or, what is no less important, to be a good follower. He learns the give-and-take of social cooperation. He learns that his individual life may be less important than the life of the group to which he belongs. The girls' group, the boys' team or gang is the first school of civics, the firm basis of a successful democracy.

The child emerges from the grammar-school age changed in many respects. He has lost some of the dreamy romanticism of the age of dramatic play and has acquired a new realism, a changed attitude illustrated by one little girl, who, when asked her vocational ambitions, replied somewhat wistfully, "I'd like to be a dancer, but I guess I'll be a stenographer."

The boy or girl of fourteen stands on the threshold of adult life. Soon adolescence will precipitate the child into a bewildering world of strange, mature emotion. He will be called upon to make decisions upon which his subsequent happiness may depend. He will be called upon to take his place in an unaccustomed adult world. We shall find him, as an adolescent, difficult to control. But if the socializing process of the grammar-school age has been well accomplished we shall have no reason for anxiety. For this is the key to a successful adolescence, just as the latter is the key to well-adjusted adulthood.

I close with the hope that the grammar-school age may cease to be the forgotten age of childhood. I feel that a better understanding of this significant, important and interesting age period will be the key to the solution of many pressing problems of individual and social conduct.

STELLAR GUESTS

By Dr. F. ZWICKY
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Stars to the ancients were symbols of the eternal and unchangeable. From observations with the unaided eye our ancestors concluded that stars were fixed objects patched on a celestial sphere, objects which did not show any signs of physical changes in time.

To-day, from observations with powerful telescopes, we know that the vast spaces beyond the sun and its planets, and the stars which inhabit these spaces, possess a life and a history all their own. One of the major problems of modern astronomy is to answer the basic questions of the life and history—namely, the origin, existence and death of stars.

Suspicions that stars are not, after all, eternal and unchangeable must have occurred to many a keen mind among the philosophers of the past. Perhaps the first to voice this suspicion clearly was Tycho Brahe (1546–1601), son of a Swedish nobleman and one of the most eminent astronomers of all time. Tycho's suspicion was specifically aroused by the appearance of a strange new star in the constellation of Cassiopeia. This star flared up on November 7, 1572. It outshone all the others for several weeks and then gradually waned to such dimness that not even with the largest of modern telescopes can astronomers discover its remains. At its maximum the new star was at least as bright as Venus at its best, so that it could be seen in daytime. So sudden and bewildering was its appearance that Tycho hardly knew whether to trust his own eyes. His impressions are well described by his words that "It was a miracle, even the greatest of all miracles that have occurred in the whole range of nature since the beginning of the world, or one certainly to be classed with those attested by Holy Oracles, the staying of the sun in its course in answer to the prayers of Joshuah and the darkening of the sun's face at the time of Crucifixion."

Fortunately, Tycho Brahe was not entirely overcome by the miracle, but settled down to undertake measurements. The accuracy of Tycho's determination of angles is about one minute of arc (the 5,400th part of a right angle); an astounding accomplishment if we remember that the telescope had not yet been invented. As the new star of 1572 showed no proper motion, Tycho concluded that it belonged to the fixed stars, and he emphatically stated that the world beyond the planets could not by any means be unchangeable, as was then generally assumed. This recognition, as I have said before, makes Tycho the father of our modern ideas on the evolution of the universe.

Let us now examine what we know to-day about stars of the type which Tycho saw. With the aid of large telescopes, we have learned that stars are self-luminous hot bodies, ranging in surface temperature from about 2,000° to 100,000° Centigrade. Most of them are very similar to our sun, which has a surface temperature of about 6,000° Centigrade and a mass some 300,000 times that of the earth. Stars are not entirely distributed at random throughout the universe. They are rather bunched in what are called island universes or nebulae. Every nebula contains something like a billion stars. All the stars of the Milky Way form such a nebula, of which our own sun and its neighboring stars are quite humble members. This, our own galaxy or nebula, is approximately a watch-shaped affair whose center lies 30,000 light years from the earth in the direction of the constellation

of Sagittarius. Another island universe, in fact, our nearest big neighbor among extragalactic objects, is the great nebula in the constellation of Andromeda. Both our own galaxy and the nebula in Andromeda have diameters of the somewhat unimaginable size of 50,000 light years. That is, it takes light, which travels at a speed of 186,000 miles a second, about 50,000 years to traverse a nebula from one end to another. The distance from us to Andromeda is still greater, namely, about 900,000 light years. As far as we can tell from observations with the hundred-inch telescope, nebulae, unlike stars, are distributed at random up to distances of about 600 million light years.

Coming back to stars, we observe that some of them, once in a long while, become capricious, and for reasons as yet unknown increase their brightness 10,000 fold or more, at the same time spouting hot gaseous clouds into interstellar space at speeds of as much as 1,500 miles/sec. Such stars are called *novae.*

There are really two types of novae, or stellar guests, as the Chinese call them. The first type, which we designate as common novae, waxes to a maximum brightness of about 20,000 times that of the sun. Perhaps twenty common novae per year flash up in the Milky Way, and an equal number per year has been observed by Dr. Hubble, of the Mt. Wilson Observatory, in the great nebula in Andromeda.

The second class of stellar guests is made up of so-called super-novae. Super-novae are much more tempestuous than common novae. Within a few hours they may become as bright as the whole nebula in which they originate. For several weeks they shine, per unit time, as much light into space as a hundred million suns put together. It is fair to say that they represent the most colossal catastrophes of matter which man has ever been privileged to witness. There are good reasons for the assumption that Tycho's star of 1572 was such a super-nova. The study of these stars is not an easy matter. They are very exclusive, making their appearance in a given nebula only once in several centuries. Therefore, unless we are very, very lucky we have little chance to observe one of these stellar guests in the Milky Way during our lifetime.

Our knowledge of super-novae in the Milky Way is derived entirely from ancient records. The voluminous books of the Chinese astronomers are particularly illuminating. Most of the observations of novae occur in the so-called encyclopedia Wen-Hieng-Tong-Kao, which was translated by the French linguist, Biot, about a hundred years ago. In this encyclopedia we read that new stars or novae appeared in 134 B.C., 123 A.D., 173 A.D., etc. The star of 134 B.C. was also observed by the great Greek astronomer Hipparchus of Nicaea, which proves that the Chinese astronomers were not just blowing bubbles. The Chinese observations were recorded in terms which to us sound amusing. For instance, we read about the nova in 173 A.D. that

> In the second year of the epoch Ching Ping, the tenth moon, on the day of Kwei Hae a strange star appeared in the middle of Nan Mun (the "southern gate," which is one of the 31 constellations into which the Chinese subdivided the sky). It was like a large bamboo mat (the observer means that the star was scintillating and looked hazy). It displayed all the five colors, both pleasing and otherwise (red is pleasing, white is not, to the Chinese). It gradually lessened. In the sixth moon of the succeeding year it disappeared.

Fortunately, the Chinese observations as to where in the sky the stellar guests flared up, what their appearance was and how long they lasted are quite accurate. The Swedish astronomer Lundmark[1] has worked on these records and concluded that most of the novae have

[1] K. Lundmark, *Publications of the Astronomical Society of the Pacific,* 33: 225, 1921, and Lund Observatory Circular No. 8, December 31, 1932.

been located in and around the constellation of Sagittarius. This is exactly what one should expect, as the denseness of stars in this direction is by far the greatest. To-day we know that the great star clouds in Sagittarius are at an approximate distance of 25,000 light years. From this fact and the recorded apparent brightness of the Chinese stellar guests Lundmark was able to compute their absolute brightness, which came to be about that of a hundred million suns put together. Many of the new stars described by the Chinese therefore seem to have been super-novae.

With the large telescopes we are not confined to observations in our own galaxy, and our chances of finding super-novae are greatly increased. Consequently, about fifteen super-novae have been recorded during the last fifty years. The most conspicuous one appeared in Andromeda in 1885. However, the astronomers who discovered these novae in distant nebulae did not know what kind of tremendous objects they were dealing with. This is due to the fact that only in the last decade, thanks to the work of Dr. Hubble and others at the Mt. Wilson Observatory, has it been proven beyond reasonable doubt that nebulae are island universes which consist of billions of stars.[2] In addition the distances of many nebulae were determined. Hubble found for instance that the five hundred galaxies which form the great cluster of nebulae in Virgo are about seven million light years distant. As some of the novae were as bright as the whole nebula in which they appeared, it follows that their absolute brightness must have been comparable to that of a hundred million stars. This result and Lundmark's conclusions concerning the novae which were recorded by the Chinese are in surprisingly good agreement. Dr. W. Baade of the Mt. Wilson Observatory and I last year called the attention of scientists to these conclusions.[3] Working up all the material which was available on temporary stars we arrived at the following tentative views:

(1) Super-novae are initially quite ordinary stars.
(2) For reasons as yet unknown these stars explode violently and send into space, during a few weeks, an amount of radiation which corresponds to the complete annihilation of a great part of the star's mass.
(3) Super-novae, perhaps, are the grand finale of stars, marking their transition from their ordinary state of existence characterized by a relatively low density into celestial bodies of extremely high density and small diameter.
(4) Cosmic rays originate mainly in super-novae.

Just how we arrived at these conclusions can not be discussed here. However, it seems clear that further investigations on super-novae will no doubt be extremely fruitful.

From what I have said before, it is safe to conclude that in a given galaxy at least one super-nova may be expected to flare up in a thousand years. If, therefore, we could observe a thousand galaxies continually we should find about one super-nova per year. Actually the most convenient place in the sky to look for super-novae is the great cluster of galaxies in the constellation of Virgo. As this cluster contains about 500 galaxies we hope to find on the average one super-nova in two years. The Virgo cluster, although seven million light years distant, can be photographed with quite small telescopes. In fact, the large telescopes are in this respect rather

[2] In this connection reference to the extensive investigations on the nature of extra-galactic nebulae, which K. Lundmark took up in 1920, should not be omitted.

[3] W. Baade and F. Zwicky, *Proceedings of the National Academy of Sciences*, 20: 254, 1934, and 20: 259, 1934, and *Physical Review*, 46: 76, 1934.

useless, as their fields are too restricted. Good photographic objectives of four- to five-inch aperture allow a satisfactory survey of these nebulae. Amateur astronomers quite often command adequate means for such surveys. Once a super-nova is found, the big telescopes will do the rest and furnish the much desired detailed information about these gigantic explosions of stars.

In addition we intend to search for the remains of super-novae which have flared up in the past. (If these remains are, as we think, *neutron stars* they will be very inconspicuous objects in the sky and will be reached only with the largest telescopes).

In conclusion, I emphasize again that the investigations of super-novae are in their infancy. However, already enough facts are available to suggest that further studies on super-novae will lead to important information regarding the constitution and the evolution of stars. Future observations on temporary stars also may hold the key to the riddle of the cosmic rays.

All the knowledge about super-novae which we possess to-day is derived from past records. The Chinese, the Persians and the Greeks have furnished us valuable data. Tycho Brahe, Kepler, Thomas Digges,[4] Galilei, Newton, and many others who towered above the Middle Ages like the spires of the Gothic cathedrals, first formulated mathematically some of the fundamental laws which govern the happenings in the universe and which enable us to-day to investigate the rôle played by temporary stars in the eternal evolutionary processes.

[4] As the work of Thomas Digges is perhaps the least known I refer to the recent publication in the Huntington Library Bulletin V, April, 1934, by F. R. Johnson and S. V. Larkey on "Thomas Digges, the Copernican System, and the Idea of the Infinity of the Universe in 1576."

Let us also not forget the astronomers of the last generation who for the first time in history had at their command two mighty aids, the spectroscope and the photographic plate. Photographic records which these men made in Pulkowa in Russia, Kônigstuhl above Heidelberg in Germany and other observatories are still available, and it remained only for Dr. Baade to perceive their value in the study of super-novae. Such cooperation, transcending all barriers of time, race and creed, has alone made possible the consistent advance of scientific thought. In conclusion, I should like to point out that since, as far as we know, any star may become a super-nova, the theory gives us a new idea of the possible nature of the end of the earth. Should our own sun suddenly explode, this friendly planet would shortly be nothing but a cloud of hot gases drifting in space. Lest any of my hearers become alarmed, however, let me add that until we know more concerning the origin of stellar guests, the alarmists are still in the position of the lady who anxiously asked a famous astronomer, "How long, professor, did you say the sun would last?" His answer was, "A few billion years at least." The lady exclaimed, "Thank heaven, I thought it was only a million years."

After this manuscript had been prepared and sent off, Nova Herculis was discovered. The spectrum and light curve of this temporary star indicate that it falls into the class of the common novae. Professor Kolhörster in Berlin has just announced that Nova Herculis, at maximum, increased the intensity of the cosmic rays arriving on the earth by 2 per cent. This observation, if correct, is the first *direct* proof of the theory that cosmic rays originate in temporary stars, which Dr. Baade and I have suggested a year ago.[5]

[5] *Op. cit.*

THE MAGIC AGE OF ALLOYS

By A. B. PARSONS

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If I should bluntly declare that the world had made more progress in applied science and invention in the last thirty-five years than in the thirty-five *thousand* years immediately preceding, most of you would frankly charge me with gross exaggeration. But, as a matter of fact, the truth of the statement can be shown.

If I were to tell you that the biggest factor in this twentieth century progress is the amazing development in the arts of making and using alloys you would again be skeptical. And this time your skepticism would be justified, for the following simple reason: This material world of ours is so complex; each achievement is so dependent on a dozen others that no one branch of science or technology can fairly be singled out as making the preeminent contribution to progress. At the very least, however, it can be said truthfully that no one has a better claim to being the major contributor than the alloy metallurgist and the metallurgical engineer.

Useful manufactures in times of antiquity consisted principally of weapons of war such as spear-heads, arrow-heads and battle axes; and tools of peaceful industry such as knives, hammers and chisels. First, these were fashioned of stone—in the Stone Age; later of copper and bronze; and still later, beginning a few hundred years before the Christian era, the same implements were made of iron—in the Iron Age. History shows that industrial progress has kept step with improvements in the characteristic mineral material of which were made the tools, the weapons and the structures of successive epochs.

Some may contend that the Iron Age is still with us. Admittedly, lots of iron and plain carbon steel will be used in the future. But just as surely they are gradually being pushed into the background. Alloys have the spotlight; the magic age of alloys has arrived. You who listen will be surprised to learn how many of the seeming miracles of our modern everyday life depend, in unsuspected ways, on machines and tools that could not be made to perform as they do except for alloys.

Just what is an alloy? Simply stated, an alloy is a mixture or, more exactly, an amalgamation of two or more metals produced by cooling a melt containing the various ingredients in the desired proportions. But, like the art of baking good cake, for instance, the art of making good alloys requires more than throwing into a pot the right quantities of various metals and pouring the melted mixture into a mold to cool and solidify. A great deal depends on the way the constituents are added, the temperatures reached, the method of cooling; and, in fact, on the way the alloyed metal is treated after it is once cast.

Most metals can be alloyed with any others, and in almost any proportions. Sometimes an alloy consists of definite proportions of as many as six or eight metals. One light alloy, used for parts of airplane engines, contains copper, nickel, iron, silicon, magnesium and cerium, all totaling 8 per cent.; the other 92 per cent. being aluminum. The principal metals in the order of the quantity normally used by the world are, first and foremost, iron; then copper, lead, zinc, aluminum and tin. In a third group are manganese, nickel, molybdenum, tungsten, silicon, vanadium, chromium and cobalt; used, for the most part, to alloy with iron or steel. Fourth, is the pre-

cious metal group: gold, silver, platinum, palladium and the metals associated in nature with the latter two.

What is the purpose of making alloys? Simply this: to get a metallic material that has desired qualities or characteristics that no single metal possesses in the necessary degree. Fifty years ago a simple metal like iron, copper, lead or tin met the modest requirements of the manufacturer or builder. He wanted moderate hardness, strength, plasticity and durability.

To-day the demands are ever so much more complex and exacting. As a typical example, just imagine the punishment to which you subject the valves in your automobile engine when you travel for hours at an average speed of 70 or 60 or even 50 miles. Here are some of the properties required in the material used to make these valves: Great strength at temperatures approaching red heat; resistance to corrosion in the presence of hot exhaust gases; toughness, to avoid cracking; hardness to withstand wear. Nickel, chromium, silicon, manganese, tungsten and sometimes cobalt and molybdenum are combined with iron according to any one of a score of formulas. Most of the alloys include at least three of these elements in amount totaling 10 to 25 per cent. After careful heat treatment a material is produced that meets these exacting requirements remarkably well. It is fair to say that the automobiles of marvelous performance, that are commonplace to-day, could not be made except for the recent achievements of the alloy metallurgist.

Suppose we review at random some of the things with which you are familiar that depend in a vital way on alloys.

Take your radio receiving set. If your tubes burn out you cease to hear. The core of the little filament that lights up may be made of an alloy called Konel, which contains: Nickel, 73 per cent.; cobalt, 17 per cent.; iron, 6 per cent.; and titanium, 2½ per cent. A dozen vital parts of broadcasting, as well as receiving, equipment are made of alloys unknown ten years ago. Consider your telephone. You are able to make a long-distance call only because at intervals of 100 miles along the line are "repeater" stations. At these the sound waves that are your voice are amplified by vacuum tubes fitted with filaments of an alloy of platinum mixed with 5 per cent. of either nickel or cobalt. Distortion is prevented by loading coils of which the cores are a remarkable nickel-iron mixture called permalloy.

Or step into the modern kitchen. The electric range, the waffle iron, the toaster and the flatiron heat because of the electric resistance offered by a wire element made of nickel-chromium alloy. The sink, the table tops, the electric dishwasher and various containers are of attractive "white" metal. This may be an alloy called monel metal containing two thirds nickel, one third copper and a little iron; or an alloy of nickel, chromium and much iron—one of the much-talked-about group of "stainless" steels. The primary need is to resist corrosion; first, to prevent contamination of food; second, to save the energy of the housewife by keeping surfaces bright without frequent application of elbow grease for polishing.

Speaking of kitchens brings to mind eating. Many people are able to chew with passable success only because of certain tricky little structures that the dentist *now* calls "dentures" instead of just a plain "set of false teeth." For making them gold, platinum or palladium, hardened by alloying with copper or silver, are suitable. A less expensive alloy used for this purpose recently is called stellite. It contains 50 per cent. cobalt and the remainder chromium and tungsten. It is hard, tough and resis-

tant to tarnish; and, strangely enough, was first developed as a material for high-speed lathe tools because it retained its cutting qualities at very high temperatures.

You all know of the sensational developments in the field of railway transportation. To hope to compete with the airplane and the automobile, high-speed trains became necessary. Speed demanded light-weight construction, stream-line design and some type of efficient Diesel or gasoline engine for motive power. The result was the new Burlington Zephyr and the Union Pacific Streamliner, each capable of going 120 miles per hour, or twice the speed of fast steam trains. Both are made possible by alloys. The Zephyr is essentially of "stainless" steel construction; the Union Pacific train of aluminum alloy. The aluminum alloy weighs only half as much, volume for volume, as the steel alloy; but the latter has much greater unit strength and, when ingeniously put together, the finished structure weighs no more and is really stronger than the train built of aluminum. But the entire achievement, both cars and locomotives, is based on the use of special alloys.

One might explain how alloys have made modern aviation possible; how the automobile manufacturers are vitally obligated to the metallurgist; how alloys have participated in electrical-power progress; how the giant oil-refining industry depends for its success on the provision of marvelously strong and durable alloys required to make its high-pressure stills and other equipment.

As to the Army and the Navy, their effectiveness is based in large measure on alloys. A battleship, perhaps the most amazing mechanism ever made, is a complicated mass of pipes, wires and structural metal, mostly alloys of one kind and another, enclosed and protected by armor plate that is made of nickel-steel.

Contrast the crude spear of the Stone Age with the fighting airplane of today; the battle axe with the battleship. Quite as striking and significant is the contrast between the implements and mechanisms of peace in ancient and in modern times. With their furnaces and crucibles, their microscopes and testing machines of intricate variety; with their resourcefulness and patience, their ingenuity and imagination, the physical metallurgist, so-called, and his partners have wrought practical wonders surpassed by none. Thanks to them instead of stone as the one durable structural material, we have available literally thousands of useful alloys. In a real sense this difference measures progress in the material aspects of our social order.

THE BIOLOGICAL IMPORTANCE OF PRESSURE

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LIVING organisms must be constantly adapting themselves to physical changes in their environment. Among the ever varying conditions one thinks perhaps first of changes in temperature and moisture against which special mechanisms must be developed or else death ensues. There are, of course, many examples of species which exist in locations where the environment remains exceedingly constant, and under these conditions no protective mechanisms are needed. For example, parasites living within their mammalian hosts do not have to face the problem of marked variations in temperature or of moisture, and even the food supply is constant. Variations in these physical factors are also minimized for the fishes and other forms living entirely beneath the surface of the water. There are, however, other environmental factors which must be taken into consideration and of these one of the most interesting but least studied is the influence of pressure.

Pressure presents a real problem of adaptation to the fishes, for they are constantly being subjected to enormous changes as they swim in the depths of the ocean or rise toward its surface. How important these changes may be becomes evident when it is remembered that the pressure exerted by 34 feet of water is equal to one atmosphere or approximately 14.7 pounds per square inch, so that in diving that distance from the surface the pressure is doubled. Now the buoyancy of a fish is regulated to a large extent by the swim bladder, which is a sac containing air in such quantity that the specific gravity of the animal as a whole is very close to that of the liquid in which it is immersed, thus giving the most favorable weight for maintaining any position. But that is not all, for this reservoir of air directly assists its possessor to attain new levels in the water, either higher or lower; truly it is an organ of extraordinary value. The mechanism is quite automatic and very simple: The fish starts downward through swimming movements involving muscular effort, but coincident with the downward movement the specific gravity of the animal becomes constantly greater, due to the compression of the air with increasing water pressures, and gravity thus increasingly reinforces any muscular efforts. Conversely, as the fish turns upward the air expands and the animal as a whole becomes lighter than the surrounding water, so that even in the absence of further muscular effort it automatically rises to the surface. This procedure on the part of the fish is somewhat suggestive of a perpetual motion machine. Clearly, energy must be supplied from some source, a point to which we will return in a moment.

Since the volume of a gas is proportional to the pressure, the buoyant effect of the air in the swim bladder will be halved when a fish dives 34 feet below the surface. But many species normally range through depths many times greater than this; how far is not known. Certain species have been captured at depths greater than 2 miles below the surface where they would be subjected to a pressure of over 4,600 pounds per square inch. It is an old and well-known observation that when a fish is brought quickly to the surface from a considerable depth it "explodes." This is due not only to the expansion of the air within the swim bladder occurring as a direct consequence of the reduction in

pressure, but also to the dissolved gases which immediately come out of solution in a manner analogous to the bubbling of carbon dioxide from a bottle of beer on releasing the pressure. Little is known of the mechanism by which fish are able to adapt themselves to changes in pressure, but from what has been said it is evidently a process of great importance. It seems that this consists in part at least in the ability to maintain a fairly constant volume of air in the swim bladder by the absorption or excretion of gas coincident with the pressure changes. In coming to equilibrium with a new pressure work must be expanded to bring the volume of air in the swim bladder to the volume giving the correct specific gravity to the fish. Once this equilibrium is attained the animal is in a favorable position to make a quick change in its vertical position through the aid of the mechanism described in the last paragraph. Thus it becomes clear that the energy released with changes in level has its source in the potential energy stored by an unknown mechanism during the process of adjusting the quantity of air to the prevailing pressures. It should also be noted that between the time the fish reaches a new level and the attainment of an equilibrium it must make constant movements in order to prevent itself from being carried upward or downward as the case may be.

The rapidity with which pressure increases with the depth of water is of great practical importance in relation to diving operations. Workers in caissons and divers carrying on salvage work apparently withstand the relatively great pressures without difficulty. Within recent years the depth at which successful operations have been carried on has been extended to about 300 feet, where a pressure of about 130 pounds per square inch is encountered. The danger comes in returning to atmospheric pressure, and it is necessary to exercise great caution in order to avoid the sudden release of nitrogen gas from solution into the tissues where it causes serious symptoms known as the "bends" or caisson disease. The effect is analogous to the changes already mentioned which occur when deep-sea fishes are brought to the surface. In practice the serious effects resulting from a diminution of pressure are largely avoided by bringing about the change gradually so that the gases coming out of solution in the tissues may be gotten rid of as fast as formed. Various devices are now employed in deep-sea salvage work in which the diver is encased in a rigid suit, thus permitting him to carry on operations at greater depths than would otherwise be possible, because under these conditions increased pressures are avoided. Danger from caisson disease is thus eliminated and the diver may be brought quickly to the surface without danger.

It is not only the water forms of life that are subjected to pressure changes, for the whole surface of the earth undergoes variations in atmospheric pressure from day to day, and the decrease in pressure at high altitudes is very considerable. It is not probable that normal variations in pressure are sufficient to exert an appreciable influence on animal or plant life. On the other hand, birds, as well as mountain climbers, and aviators, experience large pressure changes. At an altitude in the neighborhood of 18,000 feet, which corresponds to that of some of the higher mountain peaks, the atmospheric pressure is only half that existing at sea level. Very much smaller pressure differences may be appreciated under certain conditions. Moderately rapid changes of but a few hundred feet in altitude give certain individuals definite sensations referred to the ears. This occurs because of a difference in pressure on the two sides of the ear drum which is commonly not

at once equalized because of the lack of a free communication between the middle ear and the outside.

The reduction of pressure occurring with an increase in altitude is accompanied by important changes in the concentration of the gases composing the atmospheric air, and it appears to be this factor, rather than the pressure change, which accounts for the train of symptoms known as "mountain sickness" which many individuals experience before becoming acclimated to high altitudes. Under these circumstances the study of the uncomplicated effects of low pressure becomes exceedingly difficult, and at the present time we can not say whether or not low pressure *per se* has an influence on physiological processes. On the other hand, various forms of animal life have been subjected experimentally to high pressures without serious consequences.

Gaertner, in Germany, studied the effects of increasing pressures up to 25 atmospheres on mice without observing any injurious effects, and this was true even when the pressure was applied quite suddenly. It was important, however, to release the pressure gradually if the mice were to survive. This is unquestionably due to the necessity for allowing time for the absorption of the gases escaping from solution into the tissues as the pressure is released, the situation being similar to that confronting the deep-sea divers when they return to the surface. That a high pressure is perfectly compatible with life is illustrated by the numerous deep-sea forms of animal life which inhabit the waters to a great depth. Various species of fish have been captured at depths approaching two miles, where the pressure is over 4,600 pounds per square inch. More primitive forms have been collected at still greater depths. Here there is a complete absence of light, and oxygen is present only in an exceedingly small concentration, and it is probable that the latter circumstance rather than the high pressure is the limiting factor which determines the maximum depth at which living forms can exist.

In the type of experiment which involves the exposure of the intact animal to high pressures it has been difficult to differentiate between a possible direct effect of the pressure and that due to the accompanying change in concentration of the surrounding gases, which come into equilibrium with the blood and tissues. This difficulty may be avoided and the experimental conditions simplified by using isolated tissues for the study of the effects of pressure on function. The tissue is completely immersed in a fluid through which the pressure changes are transmitted, and under these circumstances pressure can be applied without introducing changes in the concentration of the materials in the tissues or in the surroundings, except in so far as they may be the result of the volume changes in the fluid system. Fluids are commonly regarded as incompressible, but if this were strictly the case it is difficult to see how hydrostatic pressure could have any influence on the physiological processes going on within the cell. As a matter of fact physicists have found that a pressure of 1,000 atmospheres acting on a quantity of water will reduce its volume by 4 per cent. but that given increments of pressure produce smaller and smaller effects as the total pressures become greater. Accompanying the volume change are various alterations in the properties of compressed liquids. With the exception of water, the viscosity is increased, the dissociation of electrolytes is increased, and the solubility may become less or greater depending upon the system studied. These facts give a reasonable basis for predicting some influence of pressure on the function of a semi-fluid system such as a living cell.

Various workers, including Professor Regnaud (1891), in France; Sir Leon-

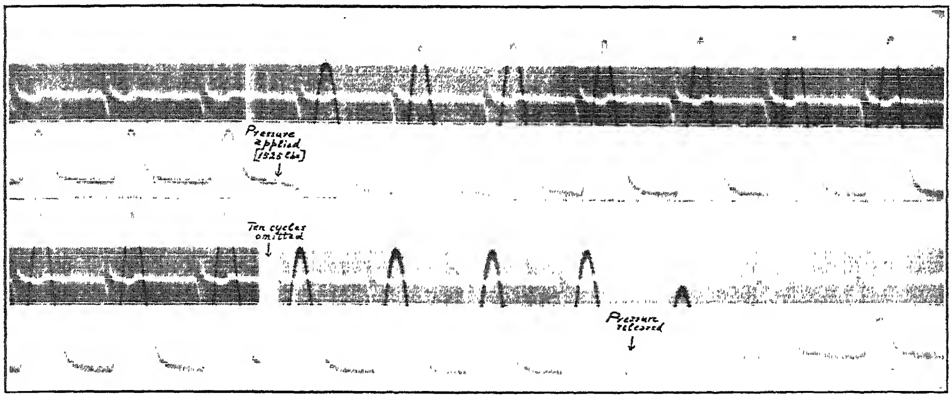


FIG. 1. PHOTOGRAPHS OF THE TENSION DEVELOPED BY A RHYTHMICALLY BEATING STRIP OF HEART MUSCLE. A PRESSURE OF 1525 POUNDS PER SQUARE INCH WAS APPLIED AND RELEASED AT THE TIMES INDICATED. THE UPPER RECORD REPRESENTS THE CHANGES IN ELECTRICAL POTENTIAL RECORDED BY MEANS OF A STRING GALVANOMETER.

ard Hill, in England (1912); and Professor Ebbecke (1914), in Germany, have studied the effect of increasing the hydrostatic pressure on the isolated muscles of the frog. They are all in agreement in indicating that pressures up to between 300 and 400 atmospheres are without immediate damaging effect on the muscle. However, when the muscle was allowed to remain under such pressures for several hours various changes were observed, including spontaneous contractions, changes in the general nature of fatigue and disorganization of the muscle structure. It is of interest to note that, with much higher pressures (6,000 atmospheres) employed by Professor Bridgman at Harvard University, egg white and ordinary meat (muscle) were coagulated at room temperature, a change resembling that occurring during the process of cooking through the action of heat. Further, it has been shown by various investigators that pressures of this order will kill bacteria. These changes are not reversible; that is, excessive pressures result in a permanent damage to the cell and so fall outside the range of normal physiological processes.

Of greater interest to the biologist is the influence of moderate changes in pressure on the functions of cells and organs. Such a study has been carried out by a group of workers in the laboratory of physiology of the Cornell University Medical College during the past few years. Thus far only a beginning has been made, but the results indicate that changes in pressure may modify physiological activity to an important extent. Some of these effects will now be described.

For the study of the action of hydrostatic pressure on muscular contraction a special chamber was constructed to withstand pressures up to 15,000 pounds per square inch. In order to study changes in the muscle while enclosed in the chamber under pressure various devices were resorted to. In the first place a heavy glass window was provided through which observations could be made. The muscle was attached to a lever upon which was a small mirror, which made possible the reflection of a beam of light into a camera. When the muscle contracted the mirror was tilted and thus a record could be made of the degree of shortening or the work done during a contraction. Further, a number of insulated electrical leads were passed into the chamber, which served various purposes at different times. Electric

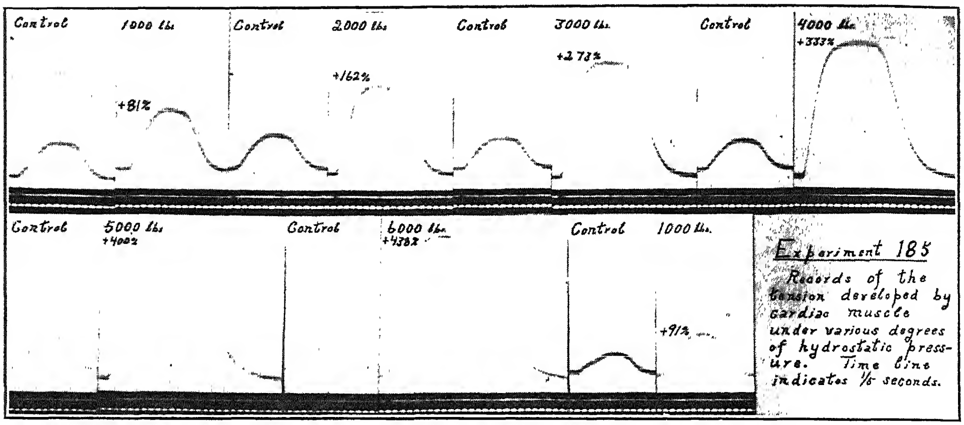


FIG 2. THE TENSION DEVELOPED BY CARDIAC MUSCLE IN RESPONSE TO A SINGLE STIMULUS AT VARIOUS PRESSURES. PHOTOGRAPHS TAKEN IN THE ORDER SHOWN, WITH CONTROLS AT ATMOSPHERIC PRESSURE ALTERNATING WITH THOSE TAKEN AT HIGH PRESSURES. PRESSURES GIVEN IN POUNDS PER SQUARE INCH.

shocks were sent into the muscle at will in order to induce a physiological contraction, and at the same time, by means of a galvanometer, the change of electrical potential in the tissue could be recorded or the heat production measured. Such in brief is the method by which we are enabled to observe muscular contraction at high pressures and to compare it with normal response taking place at atmospheric pressure.

Let us first consider the effect of increasing the pressure on a strip of heart muscle taken from the frog. Such a strip of muscle may be mounted in the apparatus and will continue its rhythmic contractions, or by properly selecting the piece of tissue a quiescent preparation may be obtained which responds with a single contraction when electrically stimulated. After studying the normal characteristics of the contraction the pressure is increased by pumping more liquid into the chamber which is transmitted throughout the entire structure of the muscle. The effect on contraction is immediate and striking in that the degree of shortening or the work done by the muscle is markedly increased. The results of such an experiment are given in Fig. 1, in which the bottom curve shows the rhythmic contractions of the turtle's auricular muscle. The muscle was attached to a stiff spring so that the peak of each of the rhythmic changes represents the pull or tension the muscle exerted and is proportional to the work done. The middle curve is a record of the electrical potential occurring in the muscle with activity and need not concern us here. In this case the application of a pressure of 1,525 pounds per square inch approximately doubled the force exerted by the beating auricular muscle.

Fig. 2 also represents the activity of the heart of a turtle, but in this case a quiescent strip of muscle from the ventricle was used. The pressure was applied in steps of 1,000 pounds per square inch up to a total of 6,000 pounds. At each pressure the muscle was stimulated and its response photographed, and this was also done in the intervals between when the muscle was at atmospheric pressure. In the figure the records are shown in the order in which they were taken. It will be seen that the stimulating action is greater the higher the pressure, the tension reaching a value at 6,000 pounds per square inch, which is more than four times that of the con-

trol. Another point which is clearly demonstrated by this experiment is that the effects of pressure are completely reversible; that is, the contraction returns to its former character as soon as the pressure is released.

Ordinary skeletal muscle from the frog may be isolated, mounted in the chamber and studied in a similar manner. When electrically stimulated such a muscle will respond with a single twitch for each electric shock. In general the effect of pressure is similar to that just described for cardiac muscle, with the difference that the changes are not so large. A typical result is shown in Fig. 3. With higher pressures the augmentation in the response becomes less and finally the direction of the influence is reversed; that is to say, the response of the muscle, at 6,000 pounds, for example, is smaller than at atmospheric pressure. At the same time the contraction is slowed, as is clearly shown in the photographic record of the twitch. Even at pressures as high as 1,000 atmospheres the twitch returns to normal when the pressure is released, provided it is not allowed to act too long.

If fatigue is produced by repeatedly stimulating the muscle or if it is cooled to a low temperature, the augmenting influence of pressure disappears and only the depressant action, just described, is observed, an effect which is now produced even by lesser pressures of the order of 60 atmospheres. As was previously mentioned, one of the most important changes resulting from the application of pressure to a fluid is a large increase in viscosity. This is true of practically all solutions except pure water which, at certain moderate pressures, has a lower viscosity than at atmospheric pressure. That high pressures do actually bring about an increase in viscosity of muscles has recently been shown by direct measurement, and it seems probable that this factor is responsible for the depression and slowing

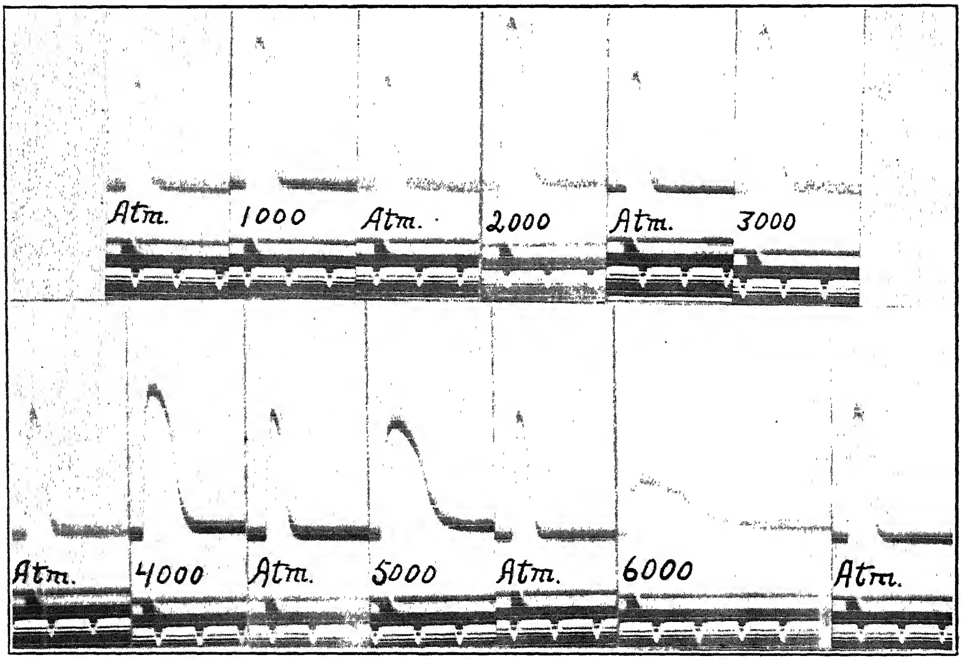


FIG. 3. THE TENSION DEVELOPED BY STRIATED MUSCLE IN RESPONSE TO A SINGLE STIMULUS AT VARIOUS PRESSURES AS INDICATED. LOWER LINE RECORDS TIME IN 1/5 SECOND INTERVALS.

of the contraction which occurs at the higher pressures. In the fatigued and chilled muscle the viscosity is abnormally high and this perhaps explains why the depression takes place at comparatively low pressures. By the combination of a low temperature and a sufficiently high pressure the size of the twitch becomes exceedingly small and may disappear altogether but recovers when the pressure is released.

The question arises as to the effect of pressure on the efficiency of the contraction. For example, is the increased tension shown in the photographs reproduced in Figures 1 and 2 due to some improvement in the conditions for transforming a given amount of chemical energy to useful work or is the effect due to an increase in the energy set free? The answer to this question comes from a study of the heat production in relation to the tension of the twitch. Since the energy of the tension developed in response to a stimulus is finally all degraded into heat with the relaxation of the muscle, the increase in temperature of the muscles gives us a direct measure of the total energy liberated. The efficiency may be represented by the ratio of the total energy to that utilized in actual work or in the development of tension. When measurements of the heat production are made simultaneously with tension records it is found that pressure results in a proportional increase of tension and heat. There is thus no evidence of an improvement in the efficiency of the mechanism through which chemical energy is converted into tension. It must be concluded that pressure causes an increased liberation of chemical energy, and it is that which is responsible for the augmentation in the size of the response.

In the case of the higher pressures which depress the muscle twitch we have, on the other hand, clear evidence of a change in efficiency. A given pressure may result in an increase in heat and a fall in tension. Under higher pressures both heat and tension become less, but the effect on the tension is always greater than that on the heat production. The magnitude of these changes denotes a maximum reduction in efficiency of about 25 per cent., which may well be due to the effects of pressure on the viscosity of the muscle substance.

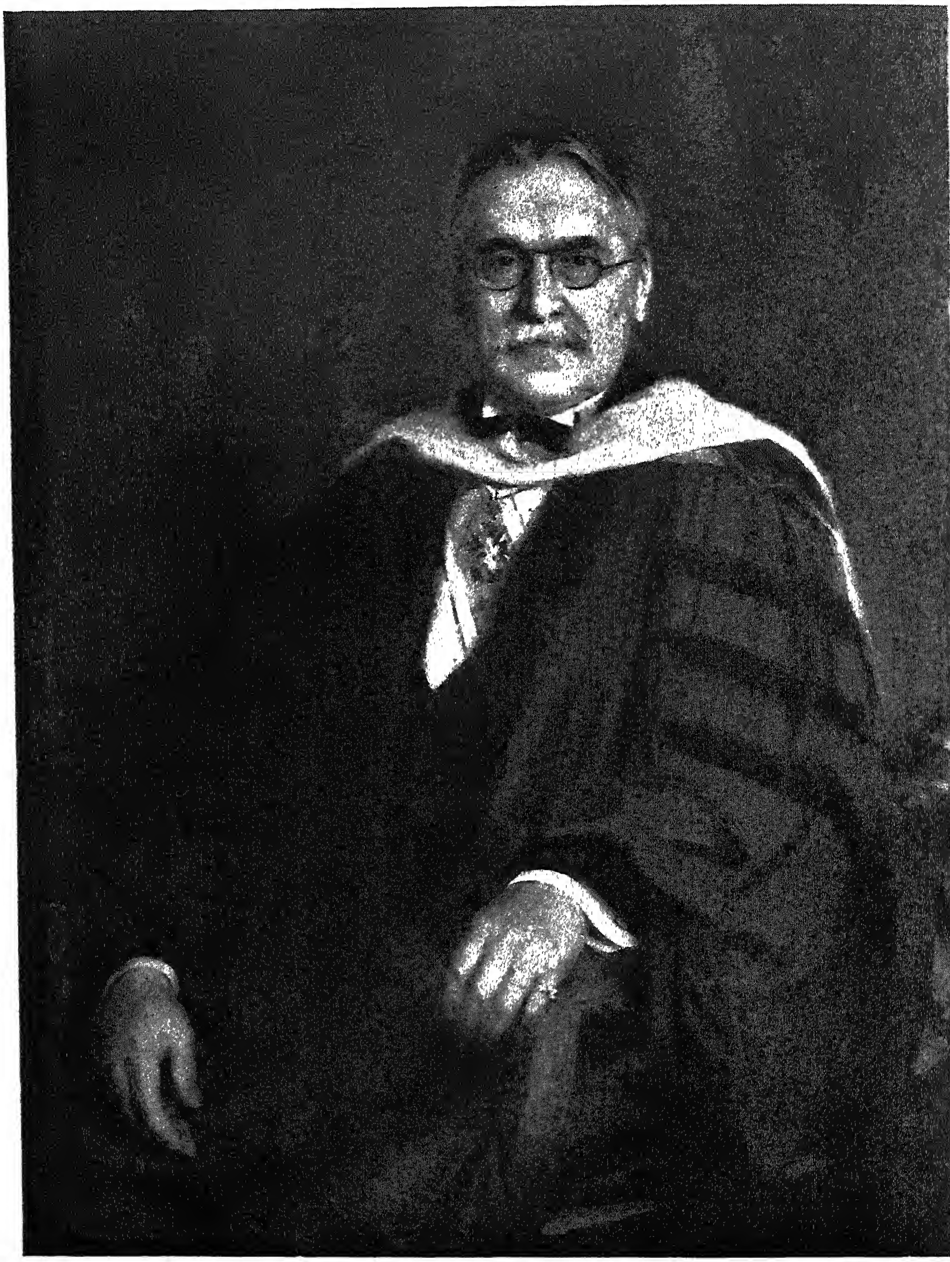
Experiments are now in progress concerning the effects of pressure on the physiological properties of nerve. Our best criterion of nerve activity is the change of electrical potential which accompanies the impulse, and this can conveniently be observed under pressure. In general the effects on nerve parallel those already described for muscle. With moderate pressures (3,000 to 8,000 pounds per square inch) we have evidence of a stimulating action in a lowered threshold of excitation, an increased velocity of propagation, and the setting up of several impulses by a stimulus normally producing but a single response. High pressures (8,000 to 15,000 pounds) markedly slow the velocity of the nerve impulse, decrease its magnitude as indicated by the action potential and raise its threshold of excitability. The interpretation of these effects is at present not clear and much further study is required.

Very much smaller pressures cause rapid loss of function when applied locally. As an illustration we may take the common experience of having a limb "go to sleep" following the prolonged application of a small pressure, *i.e.*, there is a loss of sensation and a weakness, due to failure of the nerves to function normally. This results from the changes produced in the nerve at the point of application of the pressure and may in part be due to a local interference with the blood supply. Experimentally it has been shown in isolated nerve that pressure of the order of 3 pounds per square inch, which is equiva-

lent to only a few grams on the nerve segment, will, when applied locally, completely abolish the ability of the nerve to conduct impulses within a few minutes. When a limited part of a nerve trunk is subjected to increased pressure there must always be a sharp pressure gradient at the region where the compressed portion joins that at atmospheric pressure. This results in the displacement of the fluid portions of the nerve fibers and a distortion and breaking of the solid structures. This factor is entirely absent when the organism or tissue is completely immersed in a fluid through which the pressure is transmitted, as was the case in the experiments described in the last paragraph.

A further field of study, as yet practically untouched, is the influence of high pressures on embryological development. It is a relatively simple matter to expose the eggs of such forms as the fishes or frogs to increased hydrostatic pressures. In some preliminary observations made on the eggs of the marine fish *Fundulus* it was found that the rate of cell division was slowed by pressures of the order of 2,000 pounds per square inch. In eggs containing partially developed embryos such pressures completely arrested the heart beat, which remained quiescent as long as the pressure was maintained—in some instances 24 hours—but started to beat shortly after releasing the pressure. During the period of arrested heart action the circulatory system failed to develop, and young fishes hatching from such eggs showed a high incidence of developmental abnormalities and various types of monsters were produced.

It should perhaps be emphasized that pressures of the magnitude employed experimentally can have no biological significance under natural conditions, with the possible exception of their effects on deep-sea life. A knowledge of the effects of pressure on isolated organs and tissues should, however, prove useful in evaluating the physiological importance of pressure changes in the normal environment. Further, the experimental use of the pressure technique serves as a useful tool for the study of various physiological functions. Enough has been said to indicate how very imperfect is our knowledge of the effects of pressure on biological processes. It is a fruitful field of investigation from which much may be expected in the near future.



THE LATE MICHAEL IDVORSKY PUPIN

THE PROGRESS OF SCIENCE

MICHAEL IDVORSKY PUPIN

As a telephone engineer, I am glad to have this opportunity briefly to memorialize the life and work of Michael Pupin.

Pupin early espoused that phase of physical science and engineering which underlies electrical communications, and this at a time when the needs and opportunities of the telephone and telegraph art were quite neglected by scientists generally. It is true that Heaviside had hinted at some of these possibilities in his brilliant theoretical papers, and that Vaschy in France had likewise begun to realize the importance of a thorough-going theoretical discussion of telephone transmission, while Kelvin at a much earlier date had made important contributions to the problem of submarine telegraphy. But the chief expounders of electrical science during the closing decade of the nineteenth century seemed little aware of the extensive and important future which awaited the electrical transmission of intelligence, and to have excluded it almost entirely from their thoughts.

We must consider it, therefore, all the more astonishing that the erstwhile young peasant of eastern Europe, where the telephone and telegraph were virtually unheard of, and who was but lately initiated into the sciences of mathematics and physics, should have chosen the field of electrical communications for his researches. The manner in which Pupin guided his early studies and researches well indicates the reaction of the alert mind to widely differing suggestions. He reached young manhood at a time when the engineering world was actively debating the respective merits of alternating versus direct current power generating and distributing systems. Pupin, fresh from his mathematical studies, was not only fascinated by this debate which drew in the leading engineers and physicists of the day, but was equally attracted by the researches with acoustical resonators which Helmholtz had been conducting. In this way he began to sense the possible analogies between the vibrating properties of sounding bodies and electrical circuits. His early work led him to the concept of electrical tuning and to the use of tuned circuits for multiplex telegraphy. Indeed, "electrical tuning" is a term which he seems to have coined. He said it was suggested by his early associations with the Serbian bagpipe, a device which fascinated him as a boy. Here were "early impressions which had made acoustical and electrical resonance appear to me later as obvious things."

Pupin was as successful in his rearches as he was foresighted in selecting a field of study. Following his work in tuning and multiplex telegraphy, he made several fundamental contributions to the communications art, in particular, his famous loading coil as applied to long-distance telephone lines. With the advent of radio telegraphy, Pupin turned his attention to that field and performed much useful work in connection with the theory of rectification in general and electrolytic detectors in particular.

There were also periods when Pupin ventured into other dominions, particularly that of x-rays, where he recorded some of the earliest observed phenomena regarding production of secondary radiation.

The picturesque phases of Pupin's life—how he came to this country, a boy of sixteen, how he learned English while working on a farm, how he prepared for college by attending night classes in New York City and laboring at anything he could get during the day —are too well known and have been too

delightfully recounted in his autobiography to call for repetition here.

Pupin stood in the front rank of American inventors, but, like an earlier scientist whose words are often quoted, he frequently remarked that he considered his most important contributions to have been not his inventions but the young men whom, as professor of electromechanics at Columbia University, he helped to train and who later attained to eminence. As scientist, engineer and inventor, he was universally honored. As teacher, expositor or lecturer, he possessed a clarity and picturesqueness of expression, although using a language alien to that of his early training, which fascinated alike his scientific colleague and the layman. He possessed the power to write of prosaic things with the inspiration and sparkle of poetry. But above all this, and perhaps of even greater importance at a time like the present when political creeds of every sort are tumbling about us, and even the fundamental doctrine of democracy is being viciously assailed, we would do well to regard Pupin's sturdy and uncompromising loyalty to the American political ideal. He found in the liberal and tradition-free life of America an atmosphere in which his faculties could reach their widest scope, and in gratitude he strove passionately to help others of his countrymen who followed him across the ocean to attain as great a measure as might be of free and independent life.

FRANK B. JEWETT

THE SOIL MECHANICS LABORATORY AT HARVARD UNIVERSITY

THE use of earth either for construction purposes (*e.g.,* dikes, dwellings) or as a foundation for carrying structures is as old as the beginnings of human civilization. For centuries builders have witnessed gradual or sudden subsidences of their structures, sometimes with disastrous consequences, in most cases knowing all too well that the cause resided in the character of the soils on which they built. It is a perplexing fact that this tremendous amount of human experience did not crystallize into a scientific approach to the mechanics of soils until about fifteen years ago. Even to-day by far the greater proportion of earth and foundation engineering is based on purely empirical knowledge, without utilizing the possibility of analyzing stresses, strength and deformation of the soil with the help of modern soil mechanics.

Such empirical designs are only too often pure guesswork, resulting, in most cases, in a large waste of money due to overdesigning, or, occasionally, in structures that are unsafe. This condition is not entirely the fault of the engineers engaged in construction work. Just as the great complexity of the physical properties of soils and their almost infinite variety is responsible for the unusually delayed development of a science of soil mechanics, so the difficulties of this new science in its present stage of development and the requirements of a specialized training have delayed its wide-spread application. To master the subject sufficiently to be able to apply it to actual design and construction requires much more knowledge than can be gained from a theoretical course in soil mechanics. In addition, a thorough training in soil identification and in the technique of soil-testing methods is necessary. Such training can be acquired only by working for at least one year in a well-equipped laboratory under the guidance of leading men in this field. Furthermore, successful participation in research is, as experience has shown, a necessary part of the training of students who wish to become proficient in dealing with the many new problems and new types of soils that one constantly encounters in earth and founda-

DR. HARLOW SHAPLEY AND DR. AMBROSE SWASEY

DR. HARLOW SHAPLEY, DIRECTOR OF THE HARVARD OBSERVATORY, WHO GAVE THE EVENING LECTURE AT THE CLEVELAND MEETING OF THE NATIONAL ACADEMY OF SCIENCES, WITH DR. AMBROSE SWASEY, THE DISTINGUISHED CLEVELAND MECHANICAL ENGINEER AND DESIGNER OF TELESCOPES, IN WHOSE HONOR THE YERKES OBSERVATORY RECENTLY NAMED A NEWLY-FOUND ASTEROID "SWASEYA," ON THE OCCASION OF HIS EIGHTY-EIGHTH BIRTHDAY.

tion engineering. At present the number of men in the United States capable of such independent work reaches hardly one dozen. What an unusual opportunity for keen students to work themselves into a new and fascinating field with rapidly expanding opportunities in engineering, research and teaching!

Realizing that it is up to the engineering schools to train such specialists, Dean H. E. Clifford, Professor G. M. Fair and Professor A. Haertlein, of the Graduate School of Engineering at Harvard University, supported, with admirable initiative, the reorganization of studies in earth and foundation engineering, including all related subjects, on the basis of a thorough training in soil mechanics. This plan included the installation of a research and instruction laboratory, which was started two and a half years ago and is now practically complete.

Since soil-testing methods and apparatus are still in a state of rapid development, extensive studies and research were devoted to the design of the equipment of this new laboratory. As a result new apparatus were developed which contain so many decided improvements that they represent a remarkable progress in soil testing. Those features of older designs which were found to cause appreciable errors were eliminated, and other improvements were added for further increase in accuracy and for reducing the work required to perform the tests. In addition, other developments were carried out chiefly for the purpose of permitting the performance of necessary specialized research.

Probably the most important single soil test is the consolidation test, in which a cylindrical soil sample, laterally confined, is gradually compressed between porous plates. Its main purpose is to measure the rate and magnitude of volume decrease of clays and other fine-grained soils, for analyzing settlements of buildings and other structures. The development of this testing method and of the theory of consolidation of fine-grained soils, on which it is based, form an important part in the great achievements of Professor Karl von Terzaghi (Vienna, Austria), the founder of modern soil mechanics and its leading authority.

Shearing tests and unconfined compression tests permit the determination of the strength of soils. This must be known when analyzing the safety of natural and artificial slopes against movements and slides. The method of observing the volume of the sample during shearing tests, introduced by the author five years ago, has been further improved. Among the important findings to which this method has led may be mentioned the application to the mechanics of land slides. It was found that sand and gravel expand during shearing tests, while fine-grained soils, such as rock flour, or still finer soils, reduce their volume. In other words, fine-grained soils, after being deformed, must consolidate further to be able to carry the same load as before deformation. If this consolidation is delayed or prevented, it means that a part of the load or the entire load must be carried by the water in the voids, thus reducing the shearing resistance of the soil temporarily to a very small value or to zero. If horizontal forces are acting (hydrostatic forces, unsymmetrical distribution of masses or inclined stratification), then the reduced shearing resistance may result in the movement of large masses of soil. The danger of land slides of this type is always great in clay deposits that contain thin layers or partings of very fine sand or rock flour.

An outstanding single feature of the new laboratory is the development of a universal soil-loading machine, on the framework of which all the important soil tests can be performed. This results in large savings in laboratory space, in the cost of numerous separate loading devices, and, last but not least, in work-

ing time. The following tests can be performed on this universal machine:

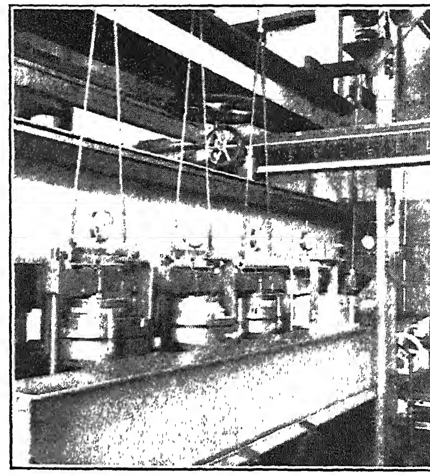
(1) *Consolidation tests:* Three such apparatus are seen in Fig. 1 on the left side of the bench; by using the entire loading bench six consolidation tests can be performed simultaneously.

(2) *Direct shearing tests:* One shearing frame can be seen to the right of the consolidations apparatus. Above the shearing frame one can see the beam which permits an automatic application of the shearing force at any desired rate. This beam is mounted on a carriage which can be moved laterally to operate at any point along the bench. Thus while samples are being prepared or while they are consolidating in other apparatus, the shearing beam can be used for testing those samples which already have reached the desired degree of consolidation.

(3) *Unconfined and semi-confined compression tests:* The loading beam, yoke and bearing plate are permanently mounted on the right end of the universal machine. However, they can be used for numerous other purposes, and in Fig. 1 this part of the equipment is being used for a consolidation test.

(4) *Direct permeability tests* for water pressures up to thirty feet. The permeability attachment is mounted on a vertical board, seen to the right of the shearing beam. It consists of a combination of a graduated standpipe, mercury manometer and air pressure tank. This device can be moved so as to operate at any position along the bench.

The laboratory includes a humid room with automatic humidity control, and is, in addition, equipped with many instruments and devices, either for soil testing and soil classification, or for demonstration and instruction purposes. With the latter, experiments can be performed with ordinary sand that are startling not only to the layman but even to experienced foundation engineers. For example, dry sand is poured into a thin



THE SOIL-LOADING MACHINE

WHICH IS CARRIED BY LARGE I-BEAMS SUPPORTED IN THE WALL, THUS ELIMINATING ALL FLOOR VIBRATIONS. THE LOWER BEAMS FORM THE LOADING BENCH ON WHICH THE SOIL-TESTING APPARATUS ARE SET UP.

rubber bag connected to a vacuum pump. As long as the air pressure on the outside and inside are the same, the bag feels very soft and the sand within can readily be moved around or deformed. However, as soon as most of the air is removed from the interior with a few strokes of the pump, the bag turns as hard as a piece of rock. Such is the effect of the weight of soil itself on the character of cohesionless sand. This experiment demonstrates simply how such sand would feel at a depth of, say, ten feet, and why the bearing capacity of sand increases very rapidly with depth. Another device consists of a tank filled with fine sand and equipped with water connections. By changing the flow of water one can demonstrate the principle of quicksand. One can also show with this device the danger which lies in producing vibrations in loose, saturated deposits. A heavy load is carried by the sand surface without any noticeable impression. Yet a slight vibration produced by driving a model pile into the sand suddenly liquefies the whole mass

of sand and the weight disappears. It is beyond the scope of this communication to go into a detailed explanation of the mechanics of these phenomena.

Among the research projects which are in progress at this laboratory, the following are of considerable importance:

(1) A comprehensive investigation of the shearing resistance of soils, including undisturbed clays.

(2) An experimental and theoretical investigation of the consolidation characteristics of undisturbed clays with particular attention to the structure of the clay and the effects of temperature.

(3) An investigation of the stress-strain characteristics of undisturbed clay beneath footings and its relation to the stress-strain characteristics of unconfined clay cylinders.

(4) Investigation of frost action in soils, rocks and building stones.

(5) Investigation of seepage through and beneath dams with particular attention to stratification and joint planes between soils of different permeability.

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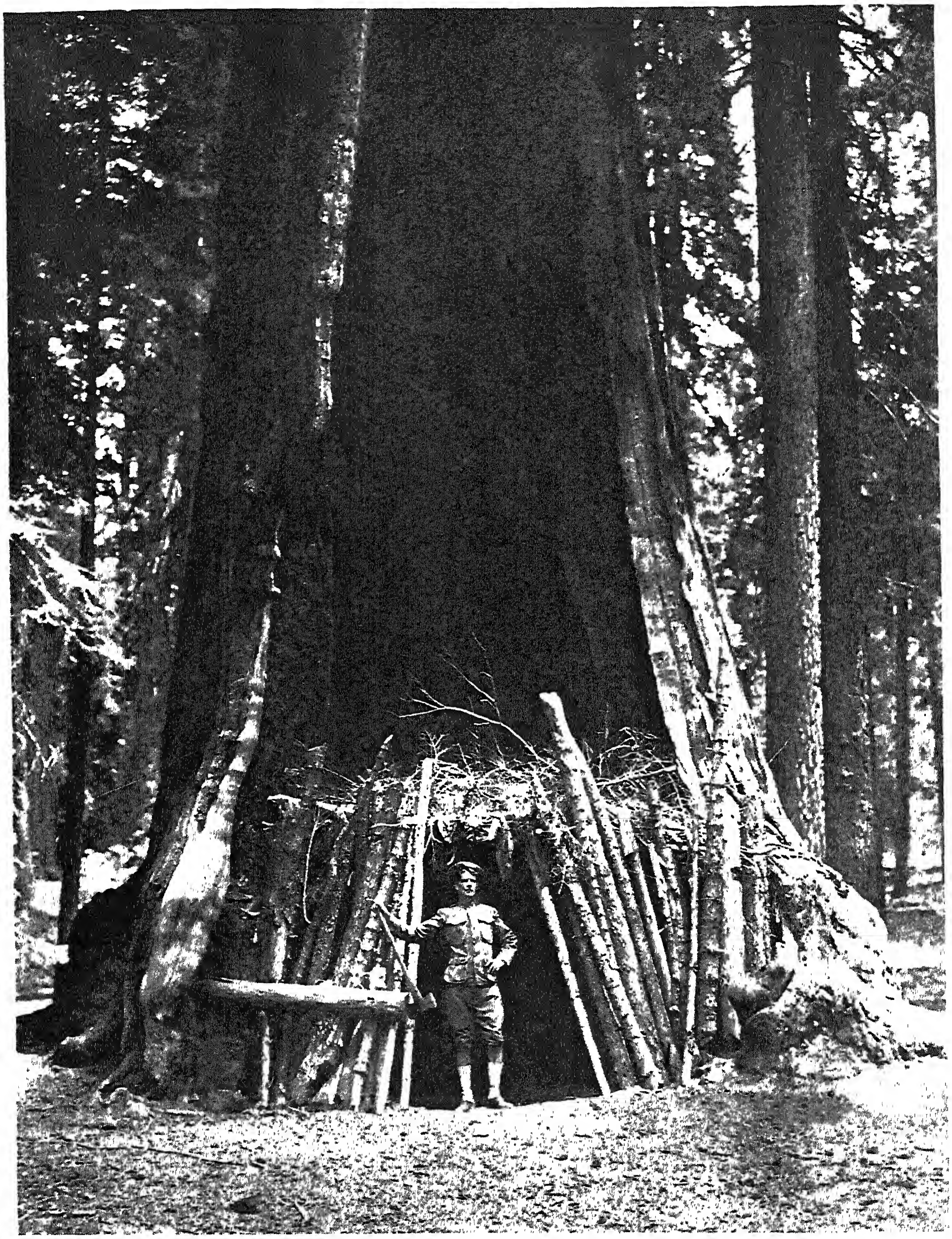
THE FALL OF A GIANT SEQUOIA

AN ordinary tree of the forest dies and little thought is given it. Trees in such infinite numbers sprout, mature, succumb to fire, insects, decay or other agencies; but when a two-thousand-year-old Giant Sequoia goes thundering earthward there is a sadness akin to losing an old friend.

The well-known Stable Tree measured the 246 feet of its length across the forest floor of the Mariposa Grove of Big Trees last August 28. Two early morning tourists on the road a hundred yards distant saw the fall, heard the crash, but because such a cloud of dust was produced by this twenty-four-foot diameter giant they didn't get out of their car! As they left the grove they casually mentioned the occurrence to the ranger. Two employees of the Big Trees Lodge, some three hundred yards distant, noticed a sliding door rattling. Thus was another monarch fallen. Rains, a few days previous, had loosened its shallow roots; a great fire scar which formed a cavity fifteen feet in diameter had removed more than one third the tree's base support; gravity did the rest. These *Sequoia gigantea* do not know how to die standing. This Stable Tree seemed flourishing. Its numerous branches and green foliage were full of newly forming cones.

The name "Stable Tree" was applied during stagecoach days. Located one hundred yards from the old log cabin, now remodeled and used as a museum, it was equipped with mangers and accommodated four horses comfortably. We marvel at changes which have taken place during the seventy-seven years this grove has been known to us. Seventy-seven years seems so short a span when we consider this tree has lived through the entire Christian era. If an individual tree rehearses the history of its race, then the Stable Tree must have been a good-sized sapling when Christ was born; it must have been approximately two feet in diameter when the Roman Empire was at its height; it must have been ten feet in diameter at the time of the first Crusade; and it must have reached practically its present size by the time the Pilgrims landed in New England.

This is the third of the grove's very large trees which have fallen during our time: The Fallen Giant, 1873; the Massachusetts Tree, 1927, and the Stable Tree, 1934. These three are all within a distance of one hundred yards of each other. Great fire scars were perhaps the principal factors contributing to their fall.



THE GIANT SEQUOIA IN THE OLD STAGECOACH DAYS

WHEN IT WAS USED AS A STABLE. IT WAS EQUIPPED WITH MANGERS AND WOULD ACCOMMODATE FOUR HORSES. THE PHOTOGRAPH WAS MADE FROM AN OLD NEGATIVE TAKEN BY THE PIONEER PHOTOGRAPHER, HOYT.

THE END OF THE GIANT SEQUOIA

Recent studies conducted by our Naturalist Department have contributed valuable information concerning the accurate dates, extent and severity of forest fires which must have raged through this grove. By scraping away the charcoal in these deep burns and by use of an increment borer, all fires attacking any given tree can be accurately determined and dated. We know, for example, that the last severe fire was in 1862 and prior to that, severe fires burned in the Stable Tree area in 1803, 1742, 1710, 1690, 1652, and so on back to A.D. 450, which at present is the earliest fire we have been able to date. It was the fire of 450 that so severely burned through the heart of the Haverford Tree, which is less than two hundred yards from the Stable Tree. It was this fire and other fires prior to 1710 which did the major portion of the burning into the great base of the Stable Tree. A comparison of these fire dates shows intervals of 59, 39, 32, 20 and 38, or an average interval between fires of 38 years for the 210 years prior to 1862. The fact that there has been no major fire during the past seventy-two years shows the important result of our fire protective measures.

The Stable Tree, prostrate, still lives as an exhibit. Thousands will marvel at its great size, the thickness of its bark and especially its remarkable resistive and self-healing powers that have made it able to live and grow in spite of tremendous injuries. It was not affected by insects; it resisted elements of decay. Its powers of resistance will remain to preserve it yet many years.

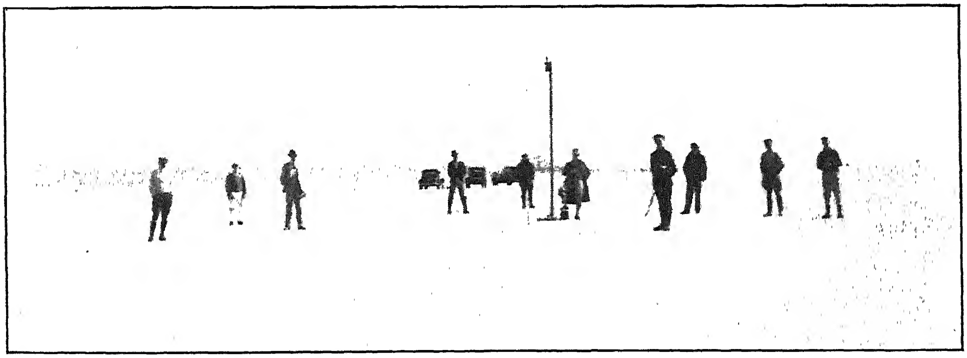
C. A. Harwell,
Park Naturalist
Yosemite National Park

ATMOSPHERIC ACOUSTICS AND THE WEATHER[1]

Every boy who has lived in the country knows that the distinct audibility of far-away trains or crowing cocks is an almost infallible sign of an approaching storm. Even the city dweller must have noticed that the hissing noise of the steam shovel or the rattling noise of the compressed-air riveter can be heard further and louder on a cold dry day in winter than on a hot sultry day in summer. These and many other common observations connecting the weather and the acoustic "transparency" of the atmosphere recently have been clarified by experiments on the absorption of sound in gases.

These experiments began five years ago with certain difficulties which were encountered in calibrating the new reverberation rooms at the University of California at Los Angeles. When the dry air from the desert lowered the relative humidity in the room to from 10 to 15 per cent. a high-pitched tone (4,000 vibrations per second) was observed to die away to inaudibility in 2.5 seconds, whereas when the humid air from the ocean filled the room this same tone would remain audible as long as 4.5 seconds. By measuring the rate of decay of sound in two reverberation rooms—one a large room and the other a small room, both finished with painted concrete—it was possible to determine the rate of absorption of sound in the air for different temperatures and humidities. Such measurements revealed the surprising result that high-pitched sounds, when propagated through the air, are absorbed from 10 to 100 times faster than had been predicted by the classical theories of Stokes and Kirchhoff—theories that had been generally accepted by physicists for the past two generations—and the absorption was found to depend upon temperature and humidity in a characteristic manner. For each sound frequency there is a certain humidity (low humidities for low-pitched tones and higher humidities for high-pitched tones) for which the air is more "opaque" than at any other humidity. Perfectly dry air is the best conductor of sound, and the colder the air the better the conductivity. This

[1] A non-technical statement of the work reported by the author at the Pittsburgh meeting of the American Association for the Advancement of Science. His paper entitled "The Absorption of Sound in Gases" was awarded the Association Prize of $1,000.—Ed.



EXPERIMENTS IN THE MOJAVE DESERT

Graduate students, Mr. L. P. Delsasso and the author measuring the attenuation of sound as it is propagated over a dry lake in the Mojave Desert. A "point" source is mounted on the top of a pole and the observers move radially away from the pole until the tone is reduced to the threshold of audibility. These experiments are being conducted to check the results obtained in the laboratory.

helps to explain the long-distance transmission of sound in the Arctic, where reports from reliable observers indicate that the ordinary sounds of speech or the barking of dogs can be heard over distances as great as ten to fifteen miles. Whereas dry, cold air is more "transparent" than any other kind of air, the addition of small amounts of water vapor or an increase in temperature greatly decreases the acoustic transparency of the air. The addition of larger amounts of water vapor (above a relative humidity of about 20 per cent.) increases the transparency again. Hot, desert air containing a relatively small amount of water vapor stifles sound more than any other kind of air does.

The experimental findings of this investigation have an immediate and important application in architectural acoustics and sound signaling. The measurement of the absorptive properties of acoustical materials, for frequencies above 500 cycles per second, can now be accomplished without introducing errors, owing to an unknown or variable absorption in the air, which in some instances have been very serious. In large auditoriums, the reverberation of the high frequency components of speech and music is affected more by the condition of the air in the room than it is by the nature of the materials which form the boundaries of the room. Thus, at a frequency of 10,000 cyles—which is now generally regarded as lying within the range of frequencies necessary for high quality sound—the value of the absorption coefficient in the air at 70° F. and 18 per cent. relative humidity is 0.020 per foot. This means that a plane sound wave of this frequency would have its intensity reduced more than 60 per cent. in traveling a distance of 50 feet. Of course, this low humidity is rarely realized in a room occupied by people, but even at a relative humidity of 50 per cent. the absorption at these high frequencies is very great—so great that it is necessary to reckon with the phenomenon of sound absorption in air in the design of sound-reproducing equipment, especially for large theaters or out of doors.

Sound signaling in the air by means of high frequency beams encounters serious limitations because of the absorption in the air. For example, at a temperature of 70° F. and a relative humidity of 14 per cent., the value of the absorption coefficient at 6,000 cycles is 0.012 per foot. Under these circumstances such a beam of sound would be reduced to one millionth of its initial intensity after traveling a distance of about 1,200 feet. It is obvious, therefore, that such a high frequency sound is not suitable for acoustic signaling, as, for example, for acoustic altimeters in aircraft. Tones of lower frequency—about 2,000 cycles—are more suitable for long-range signaling. The most favorable frequency will not be the same for different conditions of temperature and humidity, but for known weather conditions it is possible by means of these recent experiments to calculate the most favorable signal frequency.

The theoretical interest in these new results is perhaps even more significant than their practical applications. Thus, the experimental results have been satisfactorily explained by Dr. H. O. Kneser, of Marburg, Germany, by assuming that collisions between oxygen molecules and certain other molecules, as water molecules, result in the transfer of translational and vibrational energy. A new technique is thus available for investigating molecular phenomena. Already, interesting data have been obtained concerning the nature of the forces involved in molecular collisions, and it is in this field that the new experiments on sound absorption promise to be most useful.

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THE IGNEOUS ROCKS IN THE LIGHT OF HIGH-TEMPERATURE RESEARCH

By Dr. NORMAN L. BOWEN

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According to the Newtonian mechanics an object attracts another object with a force that is inversely proportional to the square of its distance. Nowadays the relativists would have us regard the matter in a somewhat different light, but I think we might, even in these parlous times, postulate safely that an object attracts the human mind with a force that is, not inversely, but directly proportional to the square of its distance. There is an old rhyme that reads:

> Twinkle, twinkle, little star,
> How I wonder what you are.

It expresses a fundamental human attitude that begins in early childhood and never leaves us. So it comes about that one who would address a public gathering upon some aspect of the stars, the moon, the depths of the ocean, the inside of an atom or other remote and relatively inaccessible object may plunge into his subject without preamble and be assured of an interested audience. But one who would speak of the scientific aspects of seemingly more familiar things, such as the igneous rocks of this earth, will perhaps be well advised to assure himself that his audience knows just what these rocks are.

When I was a boy my comrades and I ranged a countryside whose woods and waters were a never-failing source of delight. We were town boys, and our excursions, be it confessed, were often of the nature of forays. Two types of countryside lay before us. The one of these, comparatively flat and featureless, was occupied by cultivated fields with an occasional patch of woods, usually hardwood bush. Here we robbed sap-buckets in spring, orchards and hickory groves in autumn. The other type of countryside was rugged and wild, locally covered with evergreen woods, but much of it bare and barren rock. We could rob such an area of little other than its spring flowers, but this we did and robbery it was, too, for the rarest and finest always grew in sections posted against trespass. In the height of summer and in the depth of winter we turned from these lawless courses into other pursuits even more delightful—swimming and skating.

Along the borders of the lake, in whose waters we spent the golden hours of many a summer day, it was apparent even to a small boy that the flat country, stripped of its soil, was made up of flat-lying layers of rock sloping gently and shelving gradually out into deep water. This was important, for in such spots the little tads of seven or eight splashed about in shallow water and learned their first strokes in safety. But big chaps of twelve or thirteen despised such spots. We sought the rugged countryside with its correspondingly rugged shores. Here

we could dive from a rock ledge into clear, green water fifteen or twenty feet deep, or again so deep that none of us could fetch bottom. The rock was of an altogether different kind. It was red in color, totally lacking in the regular flat layering, massive, solid, hard.

The contrasted structural and other characteristics of these two types of rock were impressed upon us in other ways. Both rocks were quarried and we loved to watch the quarrying operations. The layers of limestone, for we may now give the rocks their accepted local names, were parted readily by means of a crowbar and, with a minimum of labor, rectangular blocks were obtained to be used extensively in all the more substantial buildings of town and country. The massive, red granite was won with greater difficulty and was used in part for "trim" in the more pretentious structures, in part for monuments. The latter use depended upon the fact that it would take a fine polish, and on the polished surface one could see that it was made up of differently colored grains, some milky white, some red or pink, some glistening black. To this color-mottling the polished rock owed a large measure of its beauty.

The quarries were magnets to us not only during active operations but even after these were abandoned, because then they ordinarily filled with water. At quarry ponds we found our first swimming of early summer and again our first skating of early winter.

Thus in one way or another we were brought into rather intimate contact with the rocks of the area. It is very difficult to be sure just when and how a knowledge of the fundamental character of an object first comes, but I believe we spontaneously reached the conclusion that the layered limestone had been laid down in water as a mud or silt. That we reached, independently, any conclusion as to the nature of the granite is greatly to be doubted. It was probably only from explanations by our elders that we gained any concept of the granite, and it was not until I grew up and studied geology that I reached an adequate concept. I then learned that my boyhood haunts had lain where an ancient sea had washed an ancient shore consisting largely of granite, and had deposited upon the granite layer upon layer of mud made up of the comminuted shells of marine organisms, which mud, upon burial under a great thickness of similar material, had become a limestone. I learned that through a study of the better-preserved shells in the limestone a picture was to be had of the life that throve in that ancient sea and that, if one examined the shells found in the successively higher horizons of the overlying stratified rocks as they outcropped on the other side of the lake, a knowledge was obtained of the development of life in ancient seas through the long ages necessary to the accumulation of the great thickness of sands and silts represented in these layered rocks. But it was not this remarkable document that I found of greatest interest, for I learned that the granite was an igneous rock, a rock that had cooled slowly from the molten condition under a thick covering of overlying rocks since removed by the wear of the elements; that the variously colored grains I had seen in it were crystals of individual mineral compounds; that these crystals, when examined in a special type of light, called polarized light, gave most interesting effects, each in its own way; and that by measuring these effects the different mineral compounds could be identified. These and other features of the igneous rocks turned my interest towards them. I have been studying them ever since.

In the interior plains of this continent a boy would not ordinarily become acquainted with igneous rocks in the raw

and in their original setting. He might, however, have the opportunity of seeing igneous rock in use as an ornamental stone, forming columns, arches and the like in the portals of public buildings. Even in a small community without imposing edifices there is always the graveyard. There each seeks, in death as in life, to outdo his neighbor in splendor, and among the monuments to this folly there are usually some fine examples of igneous rocks. They may be of any hue from nearly white through various shades of red, green and gray to black itself and the observant individual might make out on polished surfaces that the dominant tone depends upon the dominance of one or another of the crystalline mineral grains of which the rocks are composed.

I have dwelt thus upon pleasant reminiscences and have descended therefrom to the surroundings of the graveyard with the purpose of emphasizing some of the many ways in which the igneous rocks and other rocks may become a part of the ordinary concerns of the average individual, especially of one living on this continent. Dwellers of other lands may have the igneous rocks (fire-rocks) brought into their lives in much more emphatic manner, that is, as a product of volcanoes.

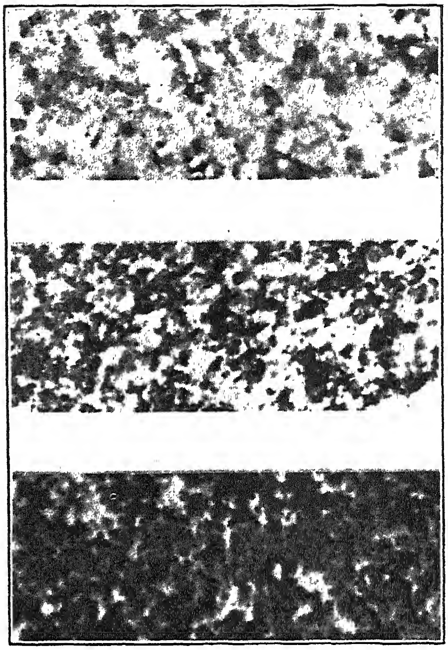

FIG. 1. PHOTOGRAPHS OF POLISHED SURFACES
OF THREE DIFFERENT IGNEOUS ROCKS SHOWING DIFFERENT PROPORTIONS OF DARK MINERALS.

Igneous Activity

Probably no more impressive spectacle is ever viewed by human eyes than that of a volcano in eruption. Close spectators of the more violent phases of vulcanicity seldom survive to relate their experiences. In the eruption of Pelée in 1902 the town of St. Pierre was wiped out by hot blasts of gas that carried incandescent rock powder. One man, who was lodged in the town's most substantial building, the prison dungeon, survived his 30,000 more respectable fellow-townsmen. Usually volcanic activity is much less destructive but scarcely less impressive. At Kilauea in Hawaii and at Namlagira in Central Africa a lava lake forms periodically in the crater pit and, impelled by escaping gases, lava fountains play freely over the surface of the lake. The lava is rock, most familiar to us as the "everlasting hills," but here converted at a high temperature into a substance that behaves almost as water in a park fountain.

At many volcanic orifices the repeated outpouring of lavas and other ejecta has built up a conical pile about the orifice. Such an arrangement of cone with central crater corresponds with the common popular concept of a volcano. In the manner indicated volcanoes often build up to such a height that their peaks are mantled with the eternal snows.

. . . a foreground black with stones and slags,
Beyond, a line of heights, and higher

All barr'd with long white cloud the scornful crags,
And highest, snow and fire.

Tennyson—The Palace of Art.

Yet great piles such as that so vividly painted in these immortal lines are not the most copious expression of surface volcanic activity. In Iceland in 1783 a fissure 20 miles long opened in the earth and lava poured out quietly at many points throughout its extent. This was but one of a series of similar incidents, some historic and some of vast antiquity, as a result of which an enormous thickness of lavas has there accumulated. In the great plateau of India that looks over the Arabian Sea from the Western Ghats a series of lavas with a total thickness as great as one mile is spread over an area of some quarter million square miles. Our own Columbia and Snake River lavas are of comparable extent and thickness.

But even such inundations are insignificant in volume compared with the great masses of molten rock—magma, as it is usually called by geologists—that have invaded the outer layers of the earth without actually reaching the surface, and have there cooled slowly and crystallized to a solid rock. After long ages of erosion the rock cover of many such masses is removed and igneous rock of a deep-seated variety is laid bare. In the Coast Range of British Columbia and Alaska there is a body of that kind some 1,200 miles long, more than 100 miles wide and of unknown but necessarily great depth. Volcanic activity is the mere froth of igneous activity, and the term, froth, is used advisedly, for it is often the expansive force of gases separating from solution in the magma to form bubbles that causes lava to flow out upon the surface. For these reasons I introduced you first to the deep-seated rocks rather than to their more showy relatives.

When the igneous rocks, deep-seated or volcanic, are examined in detail they are found to exhibit great diversity of physical, chemical and mineralogical characters. The lava of Pelée was so stiff that it was pushed through the volcanic orifice as a rigid spine which stood more than 1,000 feet above the crater. The lava lake of Kilauea is characteristically fluid. These differences are connected with differences of mineralogical and chemical composition. Indeed, petrologists have classified igneous rocks into hundreds of types as a result of detailed study of their mineral and chemical characters. The origin of this diversity is the fundamental problem of the igneous rocks. It might be argued, and with some reason, that the ultimate cause of igneous activity is the fundamental problem, but ultimate causes are as elusive here as they are in all natural phenomena. We turn, therefore, to the more tangible problem. It is possible, of course, to assume that different rock types have come into being through special acts of creation or that they have always existed as distinct entities from the beginning of time. But the petrologist finds such assumptions most unsatisfying, not solely on general principles, but because his studies reveal that different rock types found in association with each other often have certain mineral characters in common that point to a family relationship and distinguish them from other associations that show other peculiarities. The natural conclusion reached by the petrologist is that the individual members of any one group have come from a common source and that source is judged to be a common parental magma. From this magma it is supposed that the several rocks of an association have been derived through the operation of the several physical and physico-chemical processes the magma may conceivably have undergone during its career as a liquid mass and also dur-

ing the long period of slow cooling in which it changed from liquid magma to crystalline rocks. It is the task of the petrologist to ferret out these processes and to attempt to evaluate their relative importance.

The petrologist has acquired a great deal of information about rocks as such and this information must ever form the background of any investigation of the processes concerned in their origin. At the same time studies of the rocks themselves are, with respect to the active processes, distinctly post-mortem. This is superlatively true in connection with deep-seated varieties which have necessarily been cold and dead through the long ages of erosion required for their exposure at the surface. Lavas, their surface equivalents, present some little opportunity for the study of live magma, but they are dangerous playfellows and our best acquaintance even with them is as cold rock. All in all, studies of the natural materials, live or dead, raise more problems than they solve.

Laboratory Attack

In the Geophysical Laboratory of the Carnegie Institution of Washington we have sought to throw light upon the general problem by bringing to bear upon it the methods of the experimental sciences. The principal direction the investigation has taken is that of high-temperature research upon rock materials. There is nothing new in such investigations. For a century before the Geophysical Laboratory embarked upon its program, attempts had been made to study the behavior of rock materials at high temperatures. These were, to be sure, somewhat desultory and diffuse, but it was not principally from this cause that little of abiding value was accomplished. Rather was it that, apart from a few notable exceptions, most work of this kind was designed to imitate as closely as possible the actual conditions of nature. Mixtures simulating natural rocks were the subject of experiment, and the investigator thus rushed headlong into a problem almost as complex as that presented by the rocks themselves. Now it is the strength of the experimental method of attack that one can isolate the individual variables of a problem and investigate them separately. Two variables can then be combined, then three, and so on, until, by proceeding from the simple to the complex, one can build up a solution of the general problem with every unit in the structure presumably staunch and true. It is into such channels that Dr. A. L. Day has directed the activities of the Geophysical Laboratory.

The experimental investigation of rocks is a conspicuous example of the cooperative effort of a number of disciplines. The geologist brings to bear upon the problem his experience of rocks in the field. He supplies the natural history of the igneous rocks. The chemist and mineralogist determine the chemical composition of the rocks and of the individual minerals of which they are composed and at the same time measure the physical properties of the minerals. The latter is important because one and the same chemical substance may occur in two or more different forms having quite distinct physical properties. Their discrimination is of the greatest significance because the development of one or another of the several forms of an individual substance depends upon the attendant conditions. The appearance of any one form can thus often be used as a criterion of the conditions of formation, but only, of course, when all factors controlling its appearance have been determined by experiment in the laboratory. The geologist, chemist and mineralogist thus concern themselves with what may be called the materia petrologica.

The physicist brings to bear upon the

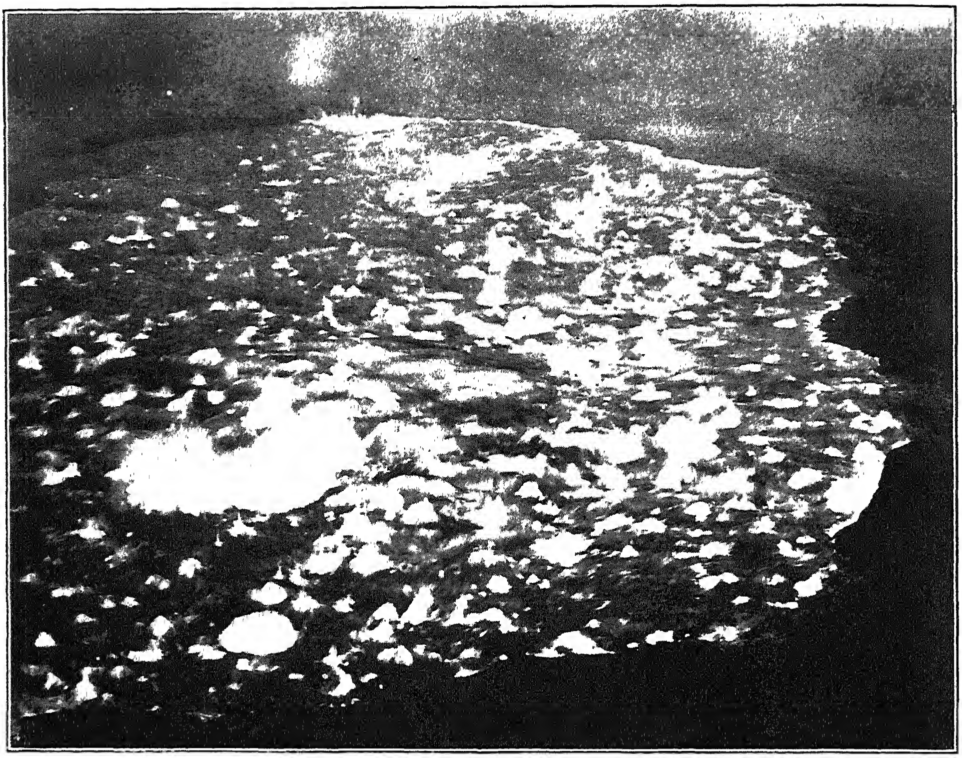

Photo by A. L. Day

FIG. 2. LAVA FOUNTAINS IN THE LAVA LAKE OF KILAUEA.

problem his knowledge of high-temperature technique with all that it implies. He must develop suitable apparatus for the obtaining, controlling and measuring of any temperature that may be required. The physical-chemist furnishes the thermodynamic theory that is absolutely essential to the prosecution of such investigations. The petrologist, primarily a geologist, contributes the natural-history setting already mentioned as required of the geologist, and with it a visualization of the broader problem and the capacity to analyze it into sub-problems. He should be expert in the application of the methods of crystal optics to the identification of his synthetic minerals, and should know that, when these methods fail in minutely crystallized substances, he can still turn to x-ray analysis. Ideally he should have a good working knowledge of all the other activities mentioned and be capable of conducting an investigation involving the use of all of them, though he will, of course, require the frequent cooperation of a colleague, expert in one of the branches. In short, he should be a jack of all trades yet master of some, a desideratum that urges tolerance of his shortcomings. Another duty is likely to fall to his lot, that of interpreting the results of his associates to geologists who specialize in other branches but wish to keep abreast of progress in all branches. It is in itself no light task. When he acquires the additional duty of interpreting to the public at large, his cup is to be regarded as indeed full.

Materia Petrologica

The natural setting of the igneous rocks and an indication of the general problem they present have hitherto en-

gaged our attention. Their chemical and mineralogical characters will now be described.

As you know, there are ninety-two fundamental chemical substances or elements. A man-made ninety-third has been announced, but scepticism prevails regarding it, and usually it is supposed that with ninety-two the possible list is complete. Now there seems no escape from the conclusion that all substances in or upon the earth, including even the atmosphere and the material parts of living organisms, must have their ultimate source in the igneous body of the earth. We should expect the igneous rocks to contain all these elements, but if they do, the proportion of the great majority of them is so small that they escape detection by the most sensitive methods. A great many others are present in such amounts that they are determined only by most careful work. Only eight elements occur in rocks in an amount exceeding 1 per cent., and here it must be remembered that we speak of rocks on the average and not of what may be found in an individual specimen. In Table I the ten most abundant elements

TABLE I

AVERAGE ELEMENTAL COMPOSITION OF IGNEOUS ROCKS

Oxygen	O	46.59	Magnesium	Mg	2.09
Silicon	Si	27.72	Titanium	Ti	0.63
Aluminum	Al	8.13	Phosphorus	P	0.13
Iron	Fe	5.01	Sulfur	S	0.052
Calcium	Ca	3.63	Copper	Cu	0.010
Sodium	Na	2.85	Zinc	Zn	0.004
Potassium	K	2.60	Lead	Pb	0.002

in the rocks are listed in the order of their abundance. They make up 99.4 per cent. so that the other eighty-two total only 0.6 per cent. To these ten have been added four others, not because they are next in order of abundance but for the purpose of indicating how small are the amounts of some every-day substances. The familiar metal copper, known even to the ancients, is excessively rare as compared with silicon, an element of considerable importance in metallurgy, to be sure, but unknown to the average individual even to-day. This is, of course, because silicon is obtained from its natural compounds only with great difficulty, whereas copper is sometimes found as such in nature and is readily obtained from its compounds. But this is not the whole story, for, were it not for certain processes of local concentration whereby masses (ore deposits) relatively rich in copper, lead or zinc are formed, the cost of recovery of these and of many other familiar metals, from rocks in general, would be prohibitive, indeed some of them might still be unknown. These processes of natural concentration of ores are of importance in connection with our general problem and we shall revert to them later.

On account of the overwhelming proportion of oxygen in rocks the various elements occur in them almost exclusively as oxygenated compounds and a chemical analysis of a rock is ordinarily stated in terms of oxides of the elements rather than as the elements themselves. The average composition of the igneous rocks stated in this form is given in Table II.

TABLE II

AVERAGE OXIDE COMPOSITION OF IGNEOUS ROCKS

Silica	SiO_2	59.12
Alumina	Al_2O_3	15.34
Ferric Oxide	Fe_2O_3	3.08
Ferrous Oxide	FeO	3.80
Magnesia	MgO	3.49
Lime	CaO	5.08
Soda	Na_2O	3.84
Potassa	K_2O	3.13
Water	H_2O	1.15
Titania	TiO_2	1.05
Phosphoric Oxide	P_2O_5	.30
Manganous Oxide	MnO	.12
all others		.50
		100.00

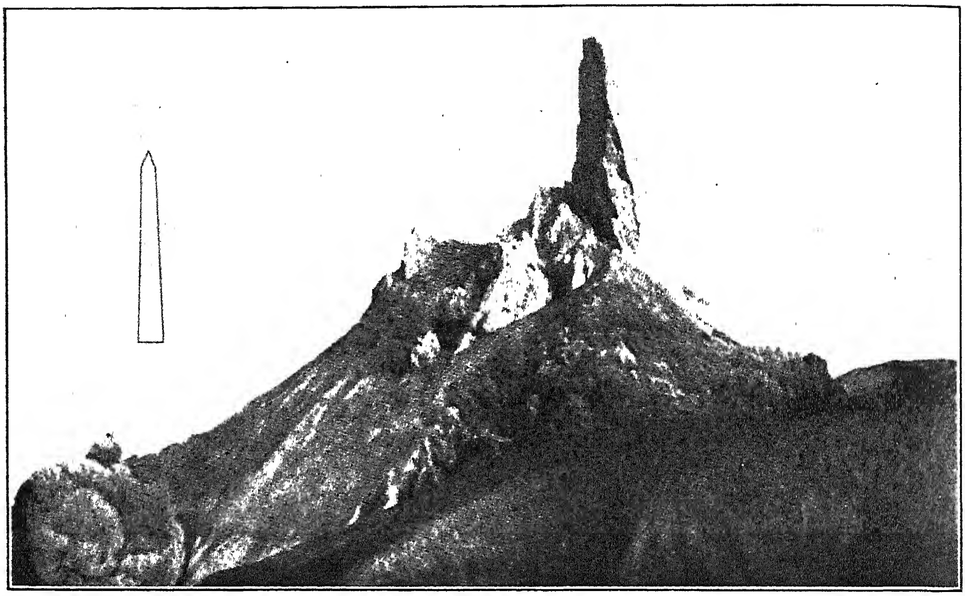

FIG. 3. THE SPINE OF PELÉE (AFTER LACROIX).
A VERY VISCOUS LAVA WAS PUSHED THROUGH THE VOLCANIC ORIFICE TO FORM THE SPINE. *Inset.* THE WASHINGTON MONUMENT ON THE SAME SCALE.

It will be noted that in both tables chemical symbols are given in addition to the name of the element or oxide. Thus in Table I the symbol for oxygen is given as O, that for iron as Fe, and so on for the other elements. In Table II the symbol for lime is given as CaO, of silica as SiO_2, and so on. These symbols convey to the chemist not only the character of the substance itself but also the exact proportions in which the elements are present that make it up. Thus CaO indicates the combination of one atom of calcium with one atom of oxygen, and since the *relative* weights of the atoms are known the exact percentage composition of lime is given when its formula CaO is given. Similarly, the formula for silica, written SiO_2, tells the chemist that two atoms of oxygen are combined with one atom of silicon and he again knows the exact percentage composition by weight. It is important to bear these facts in mind in preparation for an understanding of the more complex formulae that represent the composition of minerals.

Following the discussion of Table I little need be said of Table II. In igneous rocks, taken on the average, only 10 oxides occur in amounts in excess of one per cent. and they total a little over 99 per cent. All other oxides, together with other types of compounds, thus make up less than one per cent.

An igneous magma may be regarded as a mutual solution of the several oxides listed in Table II. No doubt they are, in large proportion, already combined into compounds. Just what these compounds are we can only surmise from the indications given by the crystalline compounds when they solidify, but of definite knowledge of the state of combination in the liquid there is none. Sometimes the liquid magma is cooled so rapidly that no crystalline minerals are individualized. The liquid simply becomes more and more viscous as it cools and even-

tually becomes a rigid substance known as a glass. Such natural glasses are reasonably common. The most common is obsidian, which will be known to many of you through its use by primitive races for arrowheads and spearheads, especially where flint was not available.

It is when magmas cool slowly and individual minerals are formed that they give their most interesting product, the crystalline igneous rocks. The list of minerals that have formed in all the various types of igneous rocks is a rather long one, but, as with rock oxides, only a few are of great quantitative importance. Because silica, SiO_2, is present in such preponderance the mineral compounds formed are for the most part silicates. It will now be our task to examine somewhat closely the common rock-forming silicates.

We may take as a simple example of a silicate the mineral formed when lime, CaO, and silica, SiO_2, combine in unit proportions. The compound $CaO \cdot SiO_2$ results. It may be written alternatively $CaSiO_3$. In either form it tells the chemist or mineralogist the exact relative proportions of calcium, silicon and oxygen contained in it, or, if one prefers, the exact proportions of lime and silica. A simple mineral of this composition is known in rocks, but only doubtfully as an igneous-rock mineral. There are usually other compounds present in a magma that ally themselves with $CaSiO_3$ to give a still more complex mineral compound. When $Al_2O_3 \cdot SiO_2$, or, alternatively Al_2SiO_5, is present, as it is in most magmas, there is formed the so-called alumino-silicate $CaO \cdot SiO_2 \cdot Al_2O_3 \cdot SiO_2$ or, as it may be written, $CaO \cdot Al_2O_3 \cdot 2SiO_2$ or again $CaAl_2Si_2O_8$. This is a very important mineral compound in igneous rocks, constituting one member of the group of minerals called feldspars. It is known as lime feldspar. The two other feldspar-forming compounds are likewise alumino-silicates but are much richer in silica, as their formulae show at a glance. They are $K_2O \cdot Al_2O_3 \cdot 6SiO_2$ (or $KAlSi_3O_8$), which is known as potash feldspar, and the corresponding soda compound $Na_2O \cdot Al_2O_3 \cdot 6SiO_2$ (or $NaAlSi_3O_8$), which is known as soda feldspar.

You will recall that when we made our first acquaintance with the igneous rocks we found that they were made up of different grains, some white or colorless, some in pale shades of red or, rarely, green, and, contrasted with these light-colored constituents, other grains that were black. Now this classification into light and dark minerals, while seemingly of superficial character, nevertheless corresponds, for all practical purposes, with fundamental chemical differences. Of the light-colored minerals the feldspars we have just discussed are the most important, indeed they are the most important of all rock minerals. If we add to the feldspars the mineral quartz (SiO_2) which is also a prominent rock mineral, we shall have included all the light-colored minerals of any great importance in rocks as a whole, though in certain rare varieties other light-colored minerals may be present even to the exclusion of these.

We turn now to the dark-colored constituents of igneous rocks. The dark minerals are iron-bearing and are dark

TABLE III

MOST PROMINENT MINERALS OF IGNEOUS ROCKS

Light-Colored	
Quartz	SiO_2
Lime Feldspar	$CaAl_2Si_2O_8$
Soda Feldspar	$NaAlSi_3O_8$
Potash Feldspar	$KAlSi_3O_8$
Dark-Colored	
Olivines	Mg_2SiO_4 and Fe_2SiO_4
Pyroxenes	mainly $CaSiO_3$, $MgSiO_3$, and $FeSiO_3$
Amphiboles and Micas	complex Fe: Mg silicates
Magnetite	Fe_3O_4

for that reason. Several mineral groups are represented and their chemistry is very complex, but the name, ferromagnesian minerals, which is often given to them as a whole, is a convenient and apt general term. The iron oxides and magnesia are prominent constituents of the dark minerals. They are absent in members of the light-colored class previously discussed.

Of the ferromagnesian mineral groups the olivines, pyroxenes, amphiboles or hornblendes, and micas are those of importance in igneous rocks. The olivines are the simplest. The magnesian olivine is $2MgO \cdot SiO_2$ or Mg_2SiO_4 and the iron olivine $2FeO \cdot SiO_2$ or Fe_2SiO_4. The pyroxenes as a group are richer in silica and in them lime becomes an important constituent. Their most prominent silicate compounds are $CaO \cdot SiO_2$, $MgO \cdot SiO_2$ and $FeO \cdot SiO_2$. The amphiboles are closely related to the pyroxenes in composition and are made up principally of the same compounds. The micas are most complex in character in that they are rich in iron oxides and magnesia but at the same time contain much potash and alumina, oxides that find their greatest prominence in the light-colored minerals. Water is an essential ingredient of both amphiboles and micas. In addition to the iron-bearing silicates, iron oxides as such are represented among the dark minerals, the most prominent being magnetite, Fe_3O_4.

The information regarding minerals that has just been detailed is presented in tabular form in Table III.

This general view of the mineralogy of the igneous rocks is necessarily very incomplete, yet it may afford an acquaintance with them that is adequate for a general appreciation of the problem presented by them. If we turn now to the average igneous rock whose chemistry has already been discussed we find that its mineral composition is that given in Table IV. Although this concept of the

TABLE IV

MINERAL COMPOSITION OF THE AVERAGE IGNEOUS ROCK

Quartz	10
Lime Feldspar	15
Soda Feldspar	32
Potash Feldspar	18
Pyroxene	20
Magnetite	5
	100

average igneous rock made up as indicated in that table is a useful one I would guard you against any false impression you may gain from it. If you should go about to examine rocks and expect to find that all or nearly all specimens you encounter will have a mineral composition approaching fairly closely to this average you have a great surprise in store for you. You will find that in some igneous rocks there is no quartz, in others it may amount to some 40 per cent. Some rocks are made up entirely of olivine yet the majority of rocks contain no olivine. Moreover, the variations are not of random character. For example, an igneous rock rich in quartz is always rich in alkali feldspars and never in lime feldspar. What are the causes underlying such association tendencies and why are there different associations? This is the problem towards whose solution our laboratory investigations have been directed.

LABORATORY METHODS

In the brief mention of the different types of investigation that are brought to bear upon the problem no details of method were given nor can they be given here. Laboratory operations are living processes and are best examined in the life. The details of methods may therefore be taken for granted and a discussion of results may be proceeded with.

The Results of High-Temperature Investigations and Their Significance

Hitherto, it has been possible, in some measure, "to gild the philosophic pill." We now come to a pill upon which, as far as I can find, no coating will take. In order to down it, it is perhaps desirable to adopt the principle of divided doses. We shall break up the pill and take only two or three small fragments now. Those who feel they have derived some benefit therefrom may administer to themselves further doses at some future time.

The presentation of the results of thermal studies of mineral compounds fills thousands of pages in scientific periodicals devoted to that and related matters. In addition, the theory of the subject and the graphical methods of presenting the results that have grown out of that theory are, in themselves, studies which many scientific men have made a life's work. It is no simple task to select from such a mass of material a part that may be discussed in a few minutes, yet shall be a fairly representative sample of the whole and at the same time give some insight into the graphical methods in common use in that connection. Man can do but his best.

A selection has already been made from rock minerals of those that are of outstanding importance. It will be to the thermal studies of these, or rather of some of these, that attention will now be directed. In the general plan of attack it has been the practice to study single oxides first and then to proceed to more complex mixtures. Of the oxides, silica, SiO_2, is by far the most important, occurring as it does in combination in nearly all rock minerals, and also free as the mineral quartz, one of the more important of the light-colored constituents. We shall, therefore, select the oxide of silicon, SiO_2, as that oxide whose thermal properties will receive special discussion.

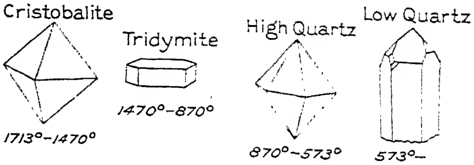

Fig. 4. The stable forms of silica and the temperature range of stability of each. Hand in hand with the difference in crystalline form goes a difference in all other physical properties, yet all are identical chemically and have the composition silicon dioxide (SiO_2).

The Forms of Silica: By heat treatment of one kind and another silica can be prepared in several different crystalline forms. One of these is identical with the natural mineral quartz and is stable at temperatures below 573° C. When it is heated to that temperature it changes promptly to another modification of silica with properties not greatly different from those of ordinary quartz but still distinctly different. The name quartz is used for both, and they may be distinguished as high and low quartz. On cooling high quartz from a temperature above 573° the change to low quartz takes place readily at or very near that temperature, many measurable properties such as volume and optical rotatory power there changing abruptly. Above 870° C. and up to 1470° C. an altogether different form of silica known as tridymite is stable, and from 1470° C. to 1713° C. yet another form known as cristobalite is the stable modification. At 1713° C. cristobalite melts, and from that temperature up to the boiling point, liquid is the stable modification.

The changes from high quartz to tridymite to cristobalite and the reverse do not take place promptly in the manner of the change from low quartz to high quartz. They are in fact very sluggish and either cristobalite or tridymite can be cooled to room temperature without suffering change to the modification stable at that temperature, *viz.*, low

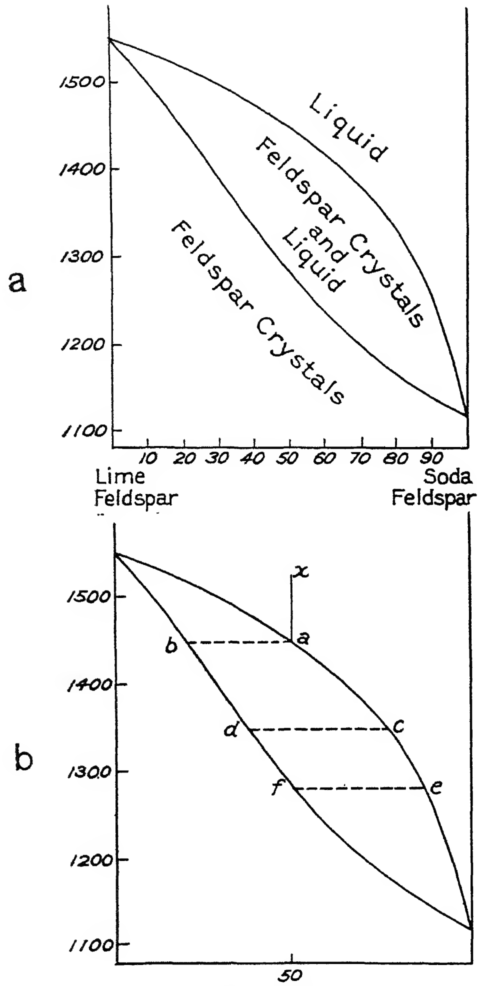

FIG. 5. (a) THE MELTING DIAGRAM OF MIXTURES OF LIME FELDSPAR AND SODA FELDSPAR SHOWING THE TEMPERATURES AT WHICH EACH MIXTURE IS COMPLETELY LIQUID, PARTLY LIQUID AND PARTLY CRYSTALLINE, AND COMPLETELY CRYSTALLINE. (b) THE SAME, SHOWING THE COMPOSITION OF THE CRYSTALS FORMED FROM EACH LIQUID. DURING CRYSTALLIZATION THE RESIDUAL LIQUID APPROACHES EVER CLOSER TO THE COMPOSITION OF SODA FELDSPAR.

quartz. Cristobalite and tridymite do show certain changes of form when so cooled, but these need not concern us here. Two other points of major significance do require mention. The first is that either tridymite or cristobalite can form at low temperatures, especially when the crystals are formed rapidly, although quartz is the stable form at these temperatures. The second point is that quartz in either the high or low modification forms only at the temperatures at which it is stable and never at high temperatures.

Now what do these laboratory results tell us about rocks? In the first place they make it clear that if primary quartz is present in a rock its crystallization from solution in the silicate liquid took place below 870°. On the other hand, if tridymite or cristobalite is present we can not be sure that it crystallized above 870°. Moreover, although all quartz is found upon examination at room temperature to be low quartz, nevertheless there are criteria whereby it can be ascertained in some cases whether it had crystallized above 573° and then changed to low quartz upon cooling or, on the other hand, had simply crystallized directly as low quartz and therefore at temperatures below 573°.

What we actually find in igneous rocks is that quartz is almost universally the form in which silica appears and the evidence is clear that it formed primarily as quartz and not as a secondary product by transformation of cristobalite and tridymite. It is, moreover, frequently possible to show that the quartz had formerly been the high-temperature variety. Thus we learn that the quartz of most igneous rocks and especially of granite, the commonest igneous rock, crystallized from the molten mixture between 870° and 573°.[1] It is frequently possible to show, also, that the quartz of mineral veins, associated with igneous rocks as an after-effect, never had been high quartz and therefore that it formed below 573°.

Mixtures of Silicates: This discussion of the modifications of silica will serve to

[1] Certain corrections of small magnitude require to be applied to these values if the rocks crystallized under high pressure, but this matter can not be discussed here.

indicate the kind of information that is obtained from the thermal investigation of a single oxide. After oxides are examined simple compounds such as $CaO \cdot SiO_2$ are next attacked, then more complex compounds, such as $CaO \cdot Al_2O_3 \cdot 2SiO_2$, and finally mixtures of compounds. Thus we approach mixtures that are related to actual rocks. The oxide already described being, in the form of quartz, a very important representative of the light-colored constituents, we shall now turn to the results obtained in mixtures of the other prominent light-colored constituents, the feldspars. Lime feldspar, $CaO \cdot Al_2O_3 \cdot 2SiO_2$, melts at 1550° C. and soda feldspar, $Na_2O \cdot Al_2O_3 \cdot 6SiO_2$, at 1122° C. What are the melting relations in mixtures of these two? These have been determined and the results are presented diagrammatically in Fig. 5 (a) and (b). In the diagram temperature is plotted in a vertical direction; the higher up we go from the base of the diagram the higher the temperature indicated. Composition is plotted in a horizontal direction. At the left of the diagram we have pure lime feldspar, at the right, pure soda feldspar, halfway between we have 50 per cent. of each and three fourths of the distance over to the right we have three fourths (75 per cent.) soda feldspar, which means of course that we have one fourth (25 per cent.) of lime feldspar. The nearer we are to the soda feldspar side the more of that compound there is present. The nearer to the lime feldspar side the more lime feldspar there is present. The diagram as a whole shows, then, the exact values of the melting points of the two feldspars and the exact melting interval of all mixtures of them. Thus we read from it that the mixture containing 50 per cent. of each begins to melt at 1287° and the melting is complete at 1450° or, if we are cooling it from a high temperature, such as that represented by the point *x*, it begins to crystallize at 1450° (point *a*), and its crystallization is complete at 1287° (point *f*). In addition the diagram tells us the composition of the crystals that are in equilibrium with any liquid. Thus the crystals that are in equilibrium with the liquid *a* have the composition *b*, the crystals that are in equilibrium with the liquid *c* have the composition *d*, and so on for other compositions and temperatures. It will be noted that the crystals in equilibrium with any liquid, that is, the crystals that will form from that liquid, are always richer in lime feldspar, and their subtraction will, therefore, always cause the liquid to be enriched in soda feldspar. The composition of the liquid therefore moves to the right along the curve *a c* as crystallization occurs with falling temperature. Now for a reason that can not be given fully here there is a definite limit to the amount of offsetting of the composition of the liquid in this manner, provided that the crystals remain suspended in the liquid, because the two react with each other or, as it may be put, the crystals absorb liquid and make it a part of their own crystalline substance. It can readily be shown that in such circumstances the liquid will not move beyond *e*, at which temperature the crystals have the composition *f* which is, of course, the same composition as the original liquid *x* or *a*. But, on the other hand, if the crystals are continually removed from the liquid, its composition will continue to migrate to the right, that is, towards soda feldspar, and there is no limit to this change of composition except the pure soda feldspar liquid itself. The kind of crystallization just described, *viz.*, that during which crystals are continually removed, is called fractional crystallization, and when I determined this diagram more than 20 years ago I was struck by the drastic effects that fractional crystallization could pro-

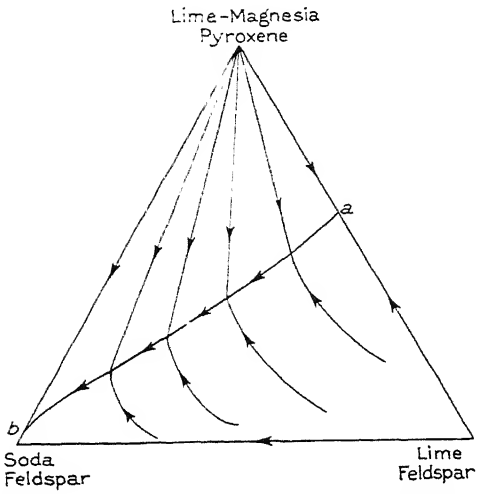

FIG. 6. DIAGRAM SHOWING BY MEANS OF ARROWS THE DIRECTION OF CHANGE OF COMPOSITION OF LIQUID DURING CRYSTALLIZATION OF MIXTURES OF LIME FELDSPAR, SODA FELDSPAR, AND LIME-MAGNESIA PYROXENE. THE LIQUID (b), VERY RICH IN SODA FELDSPAR, IS THE GOAL TOWARDS WHICH ALL LIQUIDS TREND DURING CRYSTALLIZATION.

duce in these feldspar mixtures. If we had a liquid mass of such a character in nature, and if during its crystallization the crystals sank under the action of gravity, then, in the part of the mass into which they sank there would be strong enrichment in lime feldspar, and the liquid from which they sank could be enriched in soda feldspar to the near-exclusion of lime feldspar. This is the type of relation that is actually seen in the members of an igneous-rock grouping in nature, in so far as their feldspar content is concerned. No natural magma is as simple as this pure feldspar mixture and many other effects must be going on at the same time as that described, but with this promising indication in mind it seemed desirable to push on from the feldspar mixture to other mixtures of such composition that they would throw light on these possible concomitant effects. Accordingly, a long series of investigations has been instituted, each designed to add its quota of information bearing upon the problem of fractional crystallization in silicate mixtures, with natural magmas ever in mind. A great many have been completed, several are now in progress, and definite plans are afoot for many more.

Remembering that we are still on the subject of the light-colored constituents of rocks and that we have discussed quartz and the lime-soda feldspars, we may now turn to the other light constituent of outstanding importance, *viz.*, potash feldspar. Some details of the relations of potash feldspar are still under investigation, but enough has been done to give a clear picture of the general relations. The results show that while potash feldspar bears a much more complex relation to lime feldspar than does soda feldspar, nevertheless in the effects that fractional crystallization can produce there is no great difference. In mixtures containing all three feldspars both soda feldspar and potash feldspar will be continually concentrated in residual liquids during fractional crystallization. This is again in accordance with the association tendencies of minerals in rock series and we may therefore refer this effect in natural rocks to fractional crystallization unless we find that the other constituents of rocks modify this relation so drastically that the correspondence found, apparently very significant when our information is only partial, should turn out to be mere chance coincidence when our information is more complete.

These other constituents are, of course, the dark minerals, and to these we now turn.

The Dark-Colored Constituents: The dark minerals of rocks are, as already mentioned, the iron-bearing minerals. Of all the elements that occur in rocks in an average amount greater than one per cent. the element iron is the most versatile. It occurs in three ways, as metallic iron itself, which is rare, and in two

different states of oxidation, both of which are abundantly represented. Ferrous oxide, FeO, occurs only in its compounds, whereas ferric oxide, Fe_2O_3, occurs both as such and in its compounds. The oxide, magnetite, Fe_3O_4, is conveniently regarded as a compound of ferrous and ferric oxide, for it may be written $FeO \cdot Fe_2O_3$. All the other common elements occur in rocks only in the oxidized state and as only one oxide.

The versatility of iron proved a stumbling block in the investigation of iron silicates, and for long years they resisted attempts to solve their problems by laboratory methods. The difficulty lay in controlling the state of oxidation of the iron. To keep the iron altogether in the ferric state is usually a simple matter. It is only necessary to have free access of air. But to keep the iron entirely, or almost entirely, in the ferrous state, which is the most important form entering into silicate compounds, is a more difficult matter. Some three years ago I had the good fortune to find a method of investigating the ferrous silicates that is entirely satisfactory. Since then systems have been investigated which throw much light on the iron-bearing olivines and pyroxenes. Before it had been found possible to investigate these iron-bearing minerals, a great deal had been learned of the equilibrium relations of the non-ferrous compounds that enter into the dark-colored minerals, that is, their lime and magnesia compounds, and especially of lime-magnesia pyroxenes. Moreover, lime-magnesia pyroxene had been added to the lime-soda feldspar series and equilibrium relations determined in these complex liquids containing members of the light-colored mineral groups and also members that enter into the dark-colored mineral groups. Details can not be given, but some concept of the results may be gained from the triangular diagram, Fig. 6. In this the curve *a b* may be regarded as marking the bottom of a valley towards which the liquid will flow (as indicated by the arrows) during fractional crystallization and along which it will pass towards its lowest point *b*. We are, of course, not dealing with an actual physical flow of liquid. The diagram is a composition diagram and the arrows indicate the direction of change of composition of the liquid, but the analogy with the physical flow of liquid into and along a valley may serve to make clear the facts depicted in the diagram. Now in this diagram, as in the simpler one (Fig. 5), the same principle applies that the nearer a point representing the composition of a liquid is to the corner representing one of the pure substances the richer the liquid is in that substance. Therefore the liquid *b*, which is the goal towards which all liquids change during fractional crystallization, is very rich in soda-feldspar and very much impoverished in both lime-magnesia pyroxene and lime feldspar. This is a combination of circumstances that natural rocks invariably show, and we are led to entertain seriously the hypothesis that the relations observed in the rocks are due to fractional crystallization.

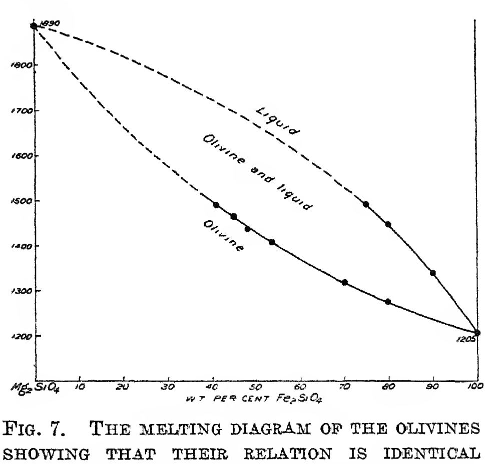

FIG. 7. THE MELTING DIAGRAM OF THE OLIVINES SHOWING THAT THEIR RELATION IS IDENTICAL WITH THAT EXHIBITED BY THE LIME-SODA FELDSPARS (FIG. 5 (a) AND (b)).

But still we have not mentioned how the ferrous ingredients of the dark-colored minerals—the very ingredients that make them dark—come into this picture. As yet the relations of the iron-bearing silicates have been determined only within two mineral groups (olivines and pyroxenes). Mixtures of them with light-colored (feldspar) constituents have not yet been studied. But in the olivine and pyroxene groups themselves it is found that the iron-rich member bears the same relation to the other members as does soda (or potash) feldspar to the lime feldspar. This fact is illustrated in the case of the olivines, by their melting diagram (Fig. 7), which is of exactly the same form as the feldspar diagram. In other words, in the dark-colored mineral groups, taken by themselves, there is a tendency for the liquid to become continually enriched in iron compounds during fractional crystallization just as there is a tendency toward alkali feldspar enrichment in purely feldspathic liquids. Therefore the question now arises: What will the net result be if these two effects occur in a single liquid of complex composition? We can not get a residual liquid that has 100 per cent. alkali feldspar and also 100 per cent. iron silicate. What balance is struck between these effects? The full answer to this question will be given only by experimental investigation, most of which is still in the future but some of which is now under way. In the meantime we can, however, be confident of this much, that if crystallization-differentiation is in control, there should be a high ratio of alkali feldspar to lime feldspar in rocks that form from residual liquids, and at the same time a high ratio of iron compounds to magnesian compounds, although we can not yet say what the absolute value of either should be. In point of fact rocks do show that a high ratio of alkali feldspar to lime feldspar goes hand in hand with a high ratio of iron compounds to magnesian compounds.

The trail we have been following appears to be most promising. We are justified in pursuing it further.

By-products

It has been mentioned that many of the most useful metals and other mineral substances are present in excessively small amounts in their source materials, the igneous rocks, and that, were it not for their local concentration in ore bodies, many of them would be scientific curiosities rather than familiar, everyday substances. It is a fact of observation, too, that certain metals tend toward association with certain types of rocks and others with other types, a condition which makes it clear that the factors controlling the derivation of rocks also control the broader distribution of valuable metals. More than this, the formation of actual ore deposits is an after-effect of igneous processes and after-effects can not be thoroughly understood without full knowledge of the processes that precede them and develop into them. Important aid in the location and exploitation of ore deposits is, therefore, a logical outcome of increased knowledge of the processes of derivation of igneous rocks.

The more tangible and more immediate practical utility of thermal studies of rock-forming oxides and silicates derives from the fact that these materials are widely used in a great variety of industrial processes.

Refractory (heat-resisting) substances are essential to such processes. Rock-forming oxides, notably silica, alumina and magnesia, and a few simple combinations of them are the principal refractory substances. They are therefore used as the materials of crucibles, furnace linings and many of the structures which it is necessary to set up in the activities connected with metallurgy, glass-making,

cement manufacture and the pottery and ceramic industry in general. Accurate knowledge of the thermal behavior of the individual oxides and of the manner and degree in which they flux each other when used together is absolutely essential to the most efficient practice in such industries. In all but one of those mentioned the actual products themselves are silicate compounds; in fact, these industries are sometimes grouped together as the silicate industries. Even in metallurgy, where the products won are metals, the slags used to flux away undesired substances are always silicate melts.

Upon all these matters our carefully controlled laboratory investigations furnish information of the utmost practical value. There is a constant flow through our laboratories of men engaged in the industries. They come to observe our methods, to obtain further information upon points not stressed in our publications or simply to express their appreciation. The discovery of mullite, a silicate of alumina, and its identification as the crystalline substance formed when clays are heated has, in itself, placed in a new light the whole subject of refractories formed from clays, which include fire brick, refractory porcelain and even every-day porcelain and pottery. Soviet Russia has had the first of the series of papers upon ferrous silicates translated into the Russian in order to facilitate its use in the many steel research laboratories established by that paternalistic government.

The great body of information upon slags, refractories and the like is an incidental product of our studies, yet there is little doubt that the value of this information to the steel industry alone will, applied through the years, greatly exceed what we received from that industry through the generosity of "the little iron-master."

Conclusion

But we must not let these side-trails lure us from the direct, if untrod, path to our goal. We seek a real understanding of the genesis of igneous rocks, and our path must lie in a broad program of sustained research. A decade or two more may bring us to a point where we can reach adequate appraisal of the hypothesis of fractional crystallization and can visualize the extent to which other processes have cooperated in producing rock diversity. Laboratory investigation of these processes will then be in order. Progress will be slow. There will be pleasant views but nothing spectacular along the way, for it is no stunt-and-gadget program. But through it we may gain increasing knowledge of our Mother Earth.

MATHEMATICS IN BIOLOGY

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I

Is it likely that mathematics, applied to biology, can be of appreciable value in the further development of that science?

This is an intriguing question. It is neither wholly historical nor wholly theoretical. It is at least both.

Some thirty years ago biology took a noticeable tack in the direction of mathematics. Biometry was the port of destination for many ships. Many others used it as an important port of call. Indeed, such an outstanding captain as Davenport spent time and energy in writing a book on mathematics for the use of biologists.

The rediscovery of Mendel's law no doubt had much to do with all this. Here was a direct and outstanding case in which one of the most fundamental phenomena in biology was found to take place according to the simplest mathematics. If one crossed a plant producing wrinkled peas with one producing smooth peas, all the hybrids would produce only smooth peas. But if one self-fertilized these hybrids it was found that on the average three plants produced smooth peas and one wrinkled. Further investigation of this second filial generation showed that two of the three plants that produced smooth peas were hybrids like the parents. One was not a hybrid but was like the smooth grandparent, not only in appearance, but in hereditary make-up. Thus the famous 1:2:1 ratio of Mendel. The finding of such a ratio governing inheritance in living plants and in animals would naturally, and did, stimulate not only research in genetics, but the use of mathematics in biology. Could any find have been happier for this twofold purpose? The ratio 1:2:1 sits in one's mind like hot toddy in one's stomach on a zero day. And if you wish to be completely convinced merely say 1:2:1 aloud, particularly before an audience.

But such is life that its continued observance, up to a certain point at least, seems to make it more complex rather than more simple. Such a large number of the skippers in the race saw the full sails of the then few genetics yachts that there was a general movement in that direction until hundreds of yachts were taking advantage of the freshening breeze Mendel had found. Under such conditions it is not surprising that in the last thirty years the course followed by these boats has become fairly well charted. This charting has led to the discovery that the 1:2:1 ratio is the exception, rather than the rule; that, indeed, there is no general mathematical rule. Gradually research in modern genetics has been moving away from quantitative study and expression. The simple algebraic formulae of a couple of decades ago are almost wholly absent from the literature. Genetics, upon coming of age, has become more and more qualitative. A large impetus in this direction was given by the discovery that mutations could be induced by x-rays. With the recent discovery of the suitability of the salivary gland chromosomes of *Drosophila,* the present leaders of the race are well-nigh all using the same new qualitative spinacker. No wonder, for it is a marvelous experience to actually see the locus of a gene deficiency in a chromosome.

Biology's most quantitative, non-hyphenated subdivision can not become qualitative without a serious repercussion in the whole science of biology.

Furthermore, the process of genetics' becoming qualitative has perhaps not been so sudden as I may have implied. Already fifteen years ago, I remember hearing a leading geneticist quoted as saying, "Biomathematics is a snare and a delusion."

It was even then obvious that while the inheritance of single, relatively unimportant characteristics might be easily amenable to simple mathematical prediction, fundamental physiological life processes did not seem to fall within the group. The factors involved appeared to be so many as to be beyond the simple statistics and probabilities of a biological laboratory. Furthermore, there was a growing question among geneticists of how far it was desirable to extend the knowledge of the inheritance of relatively unimportant characteristics. It was no longer startling news to find that inheritance of a given character in one animal or plant was similar to, or different from, that in another animal or plant.

Added to this, the idea of emergent evolution received appreciable attention. It was pointed out that two organisms, bred to each other, might produce an offspring which was neither the addition, nor a mosaic, of the two. It was further stressed that similar happenings were characteristic of all nature, inorganic as well as organic. Thus two gases, hydrogen and oxygen, when united in the right way, gave a very different third thing, water. And so on indefinitely. Now that heavy water has been discovered, perhaps the case is even more striking.

There are other important examples of the decline of mathematics in non-hyphenated biological sciences. The decline of physical anthropology is outstanding. Its offspring, growth of man, a study which has been extended until it includes the simplest animals and plants, is an excellent case in point.

Obviously, one very direct way of studying growth is to study it quantitatively. It is a very simple thing to make measurements of the growth of a person, other animal, plant, or parts of any of these. Such measurements naturally lend themselves readily to expression in mathematical terms. They give material for studies in an important part of the theory of probability: statistics, including sampling, correlation and dispersion. The data on growth are so numerous and so quantitative as to invite the attractive mathematical exercises of curve-fitting and the writing of formulae.

Such obvious possibilities have been, of course, irresistible. Many of the sailboats of mathematics-in-biology have steered their course to take advantage of the strong breezes coming from studies of growth. One might think that such strong breezes would put the mathematics-in-biology boats well in front. Almost the opposite has been the case. Indeed some of the leaders in this particular race have nearly come to the conclusion that they are caught on the edges of an air-pocket. They begin to believe that the breeze, though strong, is circular; that they are going nowhere at a fast clip.

This probably is the reason for Professor Edwin B. Wilson's[1] remarks in Volume II, Cold Spring Harbor Symposia on Quantitative Biology (1934). "One may orient oneself by some axioms or platitudes. I. *Science need not be mathematical.*" "II. *Simply because a subject is mathematical it need not therefore be scientific.*" "III. *Empirical curve fitting may be without other than classificatory significance.*" "IV. *Growth of an individual should not be confused with the growth of an aggregate (or average) of individuals.*" "V. *Different aspects of the individual, or of the average, may have different types of growth curves.*"

[1] Cold Spring Harbor Symposia on Quantitative Biology, Volume II, p. 199, 1934.

These last two headings are particularly based upon Davenport's work and conclusions. In the same volume Davenport[2] recalls some of these conclusions. "Since the hypothesis of autocatalysis relates to individual growth and not merely to mass statistics, and since no individual grows the way shown by mass growth curves, Robertson's conclusion was based on incorrect premises, and had no validity." And further, "Were there a growth-activating factor that acted on all parts of the body at the same time we might lay more stress upon the curve of body growth. But we know that the different organs grow at different rates and their maximum periods of growth occur at different times."

To make the case even more conclusive we might quote all the printed discussion of Professor Wilson's paper. The interested reader should certainly refer to it. This should be done with the realization that participants in Cold Spring Harbor Symposia on Quantitative Biology are particularly interested in the notions behind the symposia, implied in their name. With this in mind one gets a fair picture of a wide-spread disappointment in the results of the use of mathematics in the study of growth. The first sentence of Eric Ponder's[3] remarks in the discussion is significant.

> "One point upon which there seems to be pretty general agreement is that there is little relation between the amount of work which has been done on the mathematics of growth and the clarification of the subject which has resulted."*

[2] *Ibid.*, p. 203.

[3] *Ibid.*, p. 201.

*A very striking confirmation of the decline of the use of mathematics in biology, particularly in respect to biometry, is given in a note published in *Science* since the manuscript of this paper was first prepared. George G. Scott (*Science*, 81: 253, March 8, 1935) tabulated the distribution of papers in biological sciences for the past eight years, as determined by 169,744 papers received in *Biological Abstracts*. From this it appears that biometry occupies the last place in the list, accounting for 0.21 per cent., or 356 of the 169,744 papers. Scott among his conclusions justly says, "Biometry appears to be in a state of real *depression.*"

II

The picture is indeed rather depressing. But, to quote Professor Wilson again, "One may orient oneself by some axioms or platitudes," and to adopt his admirable style, we may arrive at something like the following.

I. *Mathematics can not produce valuable generalities, laws or formulae in biology when the data which it uses are insufficient.* The biological data concerning growth are very incomplete. The factors which influence the growth of a whole organism, or any part thereof, are very numerous, very incompletely understood or measured, and some almost unknown. Growth is indeed one of the most complex expressions of life processes. Extensive use of mathematics as a means of finding the explanation of such a complex and incompletely understood expression would appear, *a priori,* to be untimely, save as a pastime.

II. *Mathematics is of value in even very limited areas in which sufficient data are at hand.* Mendel's 1:2:1 ratio was found to be the exception, rather than the rule, for the inheritance of the great majority of distinguishable characteristics of an organism. Nevertheless, without the simple mathematical statement of Mendel's work, and of other early work in genetics, the unprecedented incentive to research in genetics would have been lacking, as it had been for hundreds of years. The obvious result would be non-existence of the impressive modern body of knowledge of genetics. There can be no question that all this body of knowledge has as its forebear Mendel's simple mathematical law.

III. *Mathematical expression of biological findings in terms of laws or equa-*

tions, gives significance to so-called negative findings. It is very difficult to recognize exceptions to an unexpressed law. In genetics, crossing-over, non-disjunction, deficiencies, multiple factors, indeed the long list of terms and concepts without which there would be no modern genetics, have no significance save as exceptions to Mendel's, or other simple mathematical, laws. The salivary gland chromosomes of *Drosophila* were observed years ago. The significance of the present qualitative studies upon them rests wholly upon exceptions to Mendel's law.

IV. *Mathematics may serve as a valuable measure of the state of completeness of knowledge of a science or a part of a science.* The comparative failure of the use of mathematics in interpreting findings in studies of growth indicates the colossal mass of our ignorance in respect to causes of, and factors in, growth. It should be an important stimulus to further work. Words often serve as a presentable cloak for very incomplete knowledge. Mathematics, being of scantier material, is more likely to show the skeleton lurking beneath. A biologist may smile understandingly and benignly at, "and finally, this reaction may depend upon a few other factors the nature of which we do not understand at present." He is likely to completely disregard the statement, to consider the problem well-nigh solved and to turn his attention to something else. But let the same notion be expressed by β as the known, and $f\ \lambda\rho\pi$ as the "few other factors the nature of which we do not understand at present." The biologist will now have reached the energy of activation. He will think, "The audacity of that one to assume that we will accept an equation with three unknown variables." He may even continue with his work in an attempt to reduce the functions of these variables to known quantities.

III

In a very able and readable paper a few years ago, Weaver,[4] writing on "The Reign of Probability," quotes Laplace in the introduction of his "Théorie analytique des probabilités," as follows:

> "Strictly speaking one may even say that nearly all our knowledge is problematical; and in the small number of things which we are able to know with certainty, even in the mathematical sciences themselves, induction and analogy, the principal means for discovering truth, are based on probabilities; so that the entire system of human knowledge is connected with this theory."

The fact that applied mathematics is, after all, only a matter of probabilities no doubt upsets many biologists. They are beset by complex problems in much of their research, and are constantly face to face with unknown variables. In such a working environment it would be pleasant to have some security to which one might turn as to rest billets. It would be most fortunate if the introduction of exact sciences, chemistry, physics and mathematics, into biology produced such rest billets. But it can not, for reasons pointed out by Laplace, and elaborated in clear detail by Weaver. It is obviously disappointing that facts, even in the most exact sciences, are based on probabilities. And disappointment is even greater perhaps, because too much has been expected of the use of mathematics in biology.

My personal opinion is very strong in favor of making every practicable use of exact science in biology. Probabilities are as useful here as elsewhere. Mendel's 1:2:1 ratio is itself, of course, based on probabilities. If one took a pod containing four peas resulting from a cross of "pure" smooth with "pure" wrinkled—the probability of obtaining a 1:2:1 ratio from the four hybrid seeds would be very, very slight. But

[4] THE SCIENTIFIC MONTHLY, November, 1930, p. 464.

if one had a million such pods and grew all four million resulting plants, the chances of obtaining very approximately a 1:2:1 ratio would be very good indeed. Such probabilities, if not all we need in biology, are certainly all we can expect. The fact that applied mathematics deals wholly in probabilities should in no way lessen its usefulness to biology.

There are numerous examples of the usefulness of mathematics in biology. In addition to its stimulating value to genetics, and its restraining value in the interpretation of studies on growth, which we have already mentioned in detail, a very pretty example is to be found in the history of research on the process of photosynthesis.

It is known that in ordinary chlorophyllous plants, such as sunflowers, carbon dioxide diffuses into the leaves through stomata, or holes, in one or both of the surfaces of the leaf. A difficulty of the theory, when originally proposed, was that CO_2 diffused into leaves at a rate appreciably greater than would be expected from data of the rate of CO_2 absorption on an exposed, receptive surface of known area. Due to attempts to explain this mathematical discrepancy the "diameter law" was discovered, largely as a result of the work of Brown and Escombe.[5] This law, involving diffusion gradients, is interesting not only to plant physiologists, but to other biologists, chemists, physicists and mathematicians.

The use of the theory of probabilities in biology has recently had a very lucky and impressive demonstration in the synthesizing of sex hormones from various other sterols[6]—a procedure which may be considered quite as mathematical as chemical.

[5] See H. A. Spoehr, "Photosynthesis," The Chemical Catalog Company, New York, 1926.

[6] See review by Charles E. Bills, *Physiological Reviews,* Volume 15, p. 1, 1935.

IV

It would seem to be self-evident, from the history of chemistry and physics, as well as from the history of biology, that there is likelihood that applied mathematics in biology can continue to be of appreciable value. I will extend this farther, and say that it appears to me that one may expect sufficiently valuable returns from a theoretical biology, based on mathematics, to justify its birth and controlled nurture; this in spite of the fact that there are plenty of examples of the failure of such a procedure in the past.

Various opinions are held of theoretical biology, its scope and purpose. An indication of one of these opinions may be obtained from the following remarks in a recent paper by Rashevsky:[7]

> If, however, we entertain the hope of finding a consistent explanation of biological phenomena in terms of physics and chemistry, this explanation must of necessity be of such a nature as the explanation of the various physical phenomena. It must follow logically and mathematically from a set of well-defined general principles. The collection of experimental facts gives us a lead for the establishment of the general principles. But the question as to whether a phenomenon or a set of phenomena follow from a certain experimentally established principle is in general beyond the reach of the experiment. Only in some very elementary cases can a direct inference of that nature be made from a set of experiments. In the vast majority of cases the answer to such questions belongs to the domain of deductive science. No experimenting, no matter how careful and exhaustive, could have ever established that the variation of the mass of an electron with its velocity, according to the well-known Lorentz formula, *is a consequence* of and follows from, the group of experimentally established facts leading to the principle of relativity of motion. The experimentally established impossibility of observing absolute motion on one hand, and the experimentally established fact of the variation of the mass of an electron according to a certain formula on the other hand, would have constituted two sets of unconnected facts. It required the

[7] Cold Spring Harbor Symposia on Quantitative Biology, Volume II, p. 188, Cold Spring Harbor, N. Y.

mathematical analysis by a theoretical physicist to *demonstrate* that the two sets of facts are in reality two different manifestations, two different consequences, of the same general principle.

In view of that said above it is only natural to assume that the lack of our knowledge of the fundamental causes of biological phenomena, in spite of the tremendous amount of valuable facts, is due to the lack of use of deductive mathematical methods in biology. This is being realized more and more every year and these symposia are proof of this realization. But as there are no royal roads in mathematics, we should not expect this application of mathematical methods to biology to produce miracles and to solve with one stroke all fundamental questions. In theoretical, as in experimental, research a great deal of preliminary work is necessary before final results are reached. Besides, in its future development the theoretical research will have to go hand in hand with the experimental, and ask of the latter information which may not yet be available, and for which the experimental scientist would even not have looked.

There are certain statements in this point of view to which I find it not difficult to subscribe. It is likely that at some time an appreciable number of life processes will be described in physical and chemical terms. These will then have been explained, provided physics and chemistry will have developed far and fast enough to provide the explanations. Even without bringing in analogies in physics one would seem to be justified in saying that deductive mathematical methods should have some value in helping us reach this stage. It is further pleasant to think of theoretical research asking information from the experimentalist for which the latter "would even not have looked." There is a possibility that such questions might be very useful at times. There are obviously, however, difficulties in putting it in practice immediately upon a large scale. Even when Rashevsky applies it to cell division we find the following comment from Davenport:[8]

I think the biologist might find that whereas the explanation of the division of the spherical cell is very satisfactory, yet it doesn't help as a general solution because a spherical cell isn't the commonest form of cell. The biologist knows all the possible conditions of cell form before division; cases where the cells increase enormously without dividing, and divide without increasing in size. There doesn't seem to be in any general way a relationship between the form or size in connection with the cell division. In the special cases of egg cells and cleavage spheres, this analysis may prove very valuable. But after all, these are only special cases.

To this Rashevsky[9] replied:

I have insisted on several occasions that the results presented today are only the first steps in the development of mathematical biology. It would mean a misunderstanding of the spirit and methods of mathematical sciences should we attempt to investigate more complex cases without a preliminary study of the simpler ones. The generalization of the theory, to include non-spherical cells, is indeed needed, and this will be the subject of research after the simpler cases are thoroughly and exhaustively studied. A few preliminary investigations of simplest non-spherical cases show that qualitatively the results presented today remain unchanged. To my mind it is already quite a progress, that a general physico-mathematical approach to the fundamental phenomena of cellular growth and division, as well as development of multicellular organisms, has been shown to be possible. Judging by the development of other mathematical sciences, I would say that it will take at least twenty-five years of work by scores of mathematicians to bring mathematical biology to a stage of development comparable to that of mathematical physics.

V

Meanwhile, it would seem fair to conclude that theoretical biology, in the sense outlined, should receive some attention as a definite part of biology. I would suggest that half a dozen chairs for theoretical biologists be established at biological laboratories. It has been suggested that these chairs be distributed as follows: three in this country, one in England and two on the continent. It would seem preferable to establish such chairs at research institutions, in so far as is feasible. If, however, some are established in universities, it

[8] *Ibid.*, Discussion, p. 197.

[9] *Ibid.*, p. 198.

should be clearly understood that courses should not be given in theoretical biology. This should be understood for several reasons. The holder of the chair should have as much time as he can possibly use for study and deduction. Furthermore, a professor must be uninspiring indeed who, regardless of his desires, does not, by his teaching alone, beget a number of mental sons and daughters. There are many reasons to believe that we do not wish a flock of newly hatched and hatching theoretical biologists at this time or within the next ten years, at least. What we wish is half a dozen brilliant minds to further explore the possibilities of theoretical biology, and to be in a position to become the chiefs of staff if and when recruits are needed.

Many a good thing has been run into the ground because too many hounds followed it too closely and gave too much voice to the chase. To return to our metaphor of the sailboat race, the tendency among biologists to abandon the course they were sailing in order to catch a freshening breeze somewhere else has been altogether too marked. We are too frequently given the spectacle of a large group of fairly good boats becoming relatively becalmed because there are more sails to fill than there is breeze to fill them. It seems sometimes like twelve little boys fishing. One little boy catches a good-sized fish and in no time eleven lines are within a few feet of his own, whereas the other big fish are quite likely in other parts of the lake. If we apply the theory of probabilities to theoretical biology we shall find, no doubt, that it will be wise not to expect too much from the science too soon. Consequently, we should see to it that the number of men who receive support for work in theoretical biology be kept small for the time being.

From this it should be apparent that I advocate taking no glamor, support or troops from the well-established and already very productive branches of biology. What is suggested here is to give a new branch of the service a reasonable and friendly test. It seems wholly fair to think that if we do this we shall find that mathematics, even in a relatively fundamental sense, will from time to time be of use to biology.

THE EDUCATIONAL AND OCCUPATIONAL ATTAINMENTS OF OUR NATIONAL RULERS

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THE United States, in contrast to the older countries of Europe, has been permeated with the philosophy of rugged individualism. Its rapid industrial expansion is considered the achievement of a free people unhampered by economic, social or political barriers to individual progress. No caste is said to exist, and no privileges of birth or breeding can prevent the capable boy, however lowly his origin, from reaching that enviable place in life which his abilities make possible.

Especially is this believed true in the political world. Despite the scientific evidence of biology and psychology concerning the differences among men, their political equality is guaranteed in a constitution which prescribes a representative government. Those who govern must be chosen from among us, and, if the channels of vertical movement have not become clogged during the years of our historic development, there is freedom enabling representatives of the people to rise from the humble position of the masses to the highest seats of government. If this condition prevails, our democracy has achieved a truly representative character.

But what are the facts supporting or denying the representativeness of our governing bodies? Research in this important field is scanty, probably because of the fragmentary character of usable sources. The present study is limited for this reason to an analysis of Presidents, Vice-Presidents and cabinet officers, who make up the official rulers of our commonwealth.[1] Though controlled by law, nevertheless they are the executives conducting the nation's business. Only the President and Vice-president offer themselves for the selection of the people, yet the cabinet officers chosen to make up their official families have been approved by these elected officers. They are representative of the views and aspirations of their Presidents and the political parties in which they share common membership. Consequently, they are classed with the Presidents in the eyes of the people; together they constitute the political rulers of the United States.

DISTRIBUTION OF AMERICAN RULERS

In Table I a distribution is given of the American rulers studied. A totals column has been retained in all succeeding tables, which gives the figures for all rulers from the first presidential cabinet

[1] The following sources have been consulted: "Appleton's Cyclopaedia of American Biography," edited by James Grant Wilson and John Fiske, D. Appleton and Company, New York, 1888; "Biographical Dictionary of the American Congress, 1784–1927," U. S. Govt. Printing Office, Washington, D. C., 1928; "Dictionary of American Biography," edited by Allen Johnson, Charles Scribner and Sons, New York, 1928; "The Encyclopedia Americana," The American Corporation, Chicago, 1925; "The National Cyclopaedia of American Biography," James T. White and Company, New York, 1898 to 1930; "Who's Who in America," A. N. Marquis and Company, Chicago; files of the *Army Recruiting News;* files of the *Congressional Record.*

in 1789 to the present one. Trends have been depicted by breaking up this total into periods having historic significance. The first period from 1789 to 1824 has been designated the "Colonial" with the thought that it encompasses those years when the colonies were breaking away from England and establishing the national government. The second portrayal is the "Commoner Period," ushered in by the Jacksonian democracy in 1825 and extending to Hayes' administration in 1877. During this time our westward movement took place and the spirit of the frontier dominated our national life. The third period is the "Modern," extending from 1877 to 1934. It has been called the "Plutocratic Period," by some writers because it covers the span of our big business development.

TABLE I

DISTRIBUTION OF AMERICAN RULERS

Periods	Totals: No.	Totals: Per cent.	Number of rulers: Presidents	Number of rulers: Vice-presidents	Number of rulers: Cabinet officers
All rulers 1789–1934	368	100	31	23*	314
Modern period 1877–1934	176	47.8	13	11	152
Commoner period 1825–1876	144	39.1	12	7	125
Colonial period 1789–1824	48	13.1	6	5	37

* As some Vice-presidents became Presidents they appear in the Presidents column, and not here.

It has been necessary to complicate the tables in some instances by adding percentage columns for use in making comparisons of one period with another, inasmuch as the length of periods and numbers of individuals in each are not always the same.

EDUCATION OF AMERICAN RULERS

Do our American rulers represent the average educational attainments of our people or are they a select body of men? The facts are presented in Table II.

The table reveals the fact that American rulers have always been far above the average educational level of the populace at large. Even in the commoner period, when the average education of the general population was not above the common school, almost 87 per

TABLE II

EDUCATION OF AMERICAN RULERS

Type of education	Number of rulers: All rulers	Modern	Commoner	Colonial	Per cent. of rulers: All rulers	Modern	Commoner	Colonial
Totals	368	176	144	48	100	100	100	100
College or university graduates	236	126	85	25	64.1	71.6	59.0	52.0
Attended college but not graduated	32	13	12	7	8.7	7.3	8.3	14.7
Academy or secondary school	56	18	28	10	15.2	10.3	19.5	20.8
Common school (elementary)	36	16	15	5	9.8	9.1	10.4	10.4
Limited schooling (part of elementary)	6	3	2	1	1.7	1.7	1.4	2.1
No formal schooling	2	0	2	0	0.5	0.0	1.4	0.0

cent. of the rulers had been trained in the academy, college or university. From the origin of the republic to the present administration the typical ruler has always been a college graduate.

The channel of vertical movement through which one mounts from the low levels of social origin to such high places as are occupied by rulers are not entirely closed to those so unfortunate as to possess little formal schooling. In each of the three historic periods a few individuals, 8 of the 368 rulers, have been able to overcome this handicap to win in the race for rulership.

The 10 to 12 per cent. of rulers who have not had the advantages of exceptional schooling have made use of other channels of upward movement. Of the 48 rulers who had only common school training or less, 19 were lawyers; 7 editors, publishers or authors; 4 were laborers; 1 was a farmer, and 1 a doctor of medicine. All were the product of a young, virile country in which training for the professions could be secured during apprenticeship, and where business talent could achieve eminence in an expanding industrial order which had little regard for educational or social backgrounds.

Only one poorly educated farmer succeeded in rising above his fellows, and three of the four laborers who became members of the ruling group were secretaries of labor who were chosen because of their rise to positions of power in the labor movement.

Harvard University has trained more rulers than any other institution. Only three other universities have trained more than ten rulers, namely, Yale, Princeton and North Carolina. Thirteen universities have each graduated five or more men who became rulers.

The only presidents who emerged from the masses of citizens possessing little formal schooling were four who held office during the commoner period of our history. Since the days of Johnson just following the Civil War there has not been a person occupying the White House whose educational attainments were representative of our people. From Hayes in 1877 to Franklin Roosevelt to-day, twelve of the thirteen presidents have been college trained. All thirteen have had secondary education, a degree of schooling to which only 10.2 per cent. of our population had attained by 1932.

The education of our Presidents is as follows:

Education	Total	By periods		
		Modern	Commoner	Colonial
College graduates	19	10	5	4
Attended college	4	2	1	1
Academy (Secondary)	4	1	2	1
Common school	2	0	2	0
No formal schooling	2	0	2	0

Occupations for Which American Rulers Were Trained

To make comparisons of occupations over a period of 144 years of a rapidly growing nation's life is not possible in other than relative terms, for an occupational designation, its training, income and social prestige, might have undergone significant changes during that time. Therefore, the material submitted to the reader on the occupations of our rulers has been assembled with extreme care. Groupings have been made which denote as nearly as possible distinct occupations arranged in upper and lower levels. Such a procedure permits the classification of occupations for the whole range of time, because within themselves the levels combine occupations which have had similar social connotations for the several historic periods of our national existence.

The upper level comprises professional, proprietor, managerial and large

landed proprietor occupations. While there are undoubtedly distinctions of considerable magnitude between these occupations, nevertheless they possess a certain homogeneity of cultural patterns, as expressed in relatively high incomes, prestige and similar social habits which mark them off distinctly from the manual labor occupations, small farmer and clerical workers. These latter comprise the lower level occupations, having also a similarity of cultural patterns revealed in low incomes, little social prestige and inferior cultural habits. It is impossible to push these classifications too far, for they are not infallible. Yet they are in a rough way indicative of the social significance of occupations

TABLE III

OCCUPATIONS FOR WHICH AMERICAN RULERS WERE TRAINED

Occupation	Number of rulers: All rulers	Modern	Commoner	Colonial	Per cent. of rulers: All rulers	Modern	Commoner	Colonial
Totals	368	176	144	48	100	100	100	100
Proprietors	37	22	9	6	10.0	12.5	6.2	12.5
Merchants	17	6	5	6				
Manufacturers	9	6	3	0				
Bankers and financiers	11	10	1	0				
Professions	310	144	128	37	84.0	81.8	88.9	77.1
Lawyers	272	121	118	33				
Publishers and editors	17	13	4	0				
Physicians	8	3	1	4				
Professors	5	3	2	0				
Writers	2	0	2	0				
Sociologist	1	1	0	0				
Professional-gentleman	1	0	1	0				
Managerial	4	1	3	0	1.1	0.6	2.1	0.0
Army officers	4	1	3	0				
Clerical	2	2	0	0	0.5	1.1	0.0	0.0
Private secretaries	2	2	0	0				
Agricultural	12	4	3	5	3.3	2.3	2.1	10.4
Large landowners	7	0	3	4				
Farm operators	5	4	0	1				
Manual laborers	4	3	1	0	1.1	1.7	0.7	0.0
Miners	2	2	0	0				
Tailor	1	0	1	0				
Transportation worker	1	1	0	0				
Total from upper levels	362	171	143	48	98.4	97.2	99.3	100.0
Total from lower levels	6	5	1	0	1.6	2.8	0.7	0.0

and prove extremely helpful in determining the levels from which our rulers emerge.

In Table III the occupations of American rulers have been listed, and grouped into upper and lower levels on the basis just described.

Almost 100 per cent. of all rulers come from the very peak of the occupational pyramid. Rulers are chosen from among the professions in the majority of instances. Lawyers have always possessed an entrée to political life, and this occupation still offers the easiest method of acquiring training useful in securing political appointment. The proportion of lawyers in each historic period has been high, being 68 per cent. in the modern period, 82 per cent. in the commoner and 68 per cent. in the colonial.

In terms of occupations for which they were trained presidents have been selected from the common walks of life in only one instance. The facts are as follows:

Occupation	Total	By periods		
		Modern	Commoner	Colonial
Lawyers	21	8	8	5
Army officers	3	0	3	0
Politicians—government office	2	2	0	0
Landowners	1	0	0	1
Professor	1	1	0	0
Engineer	1	1	0	0
Newspaper editor	1	1	0	0
Tailor	1	0	1	0

Comparison of Occupations of Rulers with the Occupations of Their Fathers

It appears that our rulers are a very select portion of our population from both an educational and occupational standpoint. Perhaps this is a most commendable condition, for naturally our most talented citizens should rule us. It might well be that in the United States educational opportunities are available to all who have capacity to profit thereby, irrespective of their economic or social status. The high occupational level which rulers have achieved might well represent the result of their efforts in fair competition with others. Consequently, their attainments would offer testimony to the working out in practise of our democratic principles. They would reveal what can be done when the channels of upward movement are kept open so that talent, regardless of original social position, may emerge in high place through having secured training and exhibited capacity.

Or perhaps the reverse is true, and it may be that rulers did not start from "scratch" but have had the aid of fathers or friends in substantial form, which gave them an undue advantage over all other citizens in the race for power. If such be the case, we would have little reason for self-praise, because no great measure of democracy had been achieved. We would therefore face the necessity of altering the social structure sufficiently to enable talent wherever it is located on the social pyramid to secure training and express itself.

We are unable to establish either proposition without the facts. Some of them may be ascertained from a comparison of the occupational status of rulers and their fathers. This comparison will reveal the amount of occupational climbing that has taken place, and, to the extent that occupations signify social status, the rise in social status of sons as compared with fathers. If this rise is great in amount, the democratic principle would seem to be working out well. If small and circumscribed, little upward movement would

be indicated, in which extremity we would face the necessity of enacting a sound public policy which would alter conditions in the interest of a truer democracy.

Whenever data were not sufficiently clear to permit of the tabulation of the occupations of both father and son, they were eliminated. In all 84.5 per cent. of the 368 rulers could be used, divided as follows:

Period	Total	Usable data: No.	Usable data: Per cent. of all rulers
1789–1934	368	311	84.5
Modern period	176	141	80.1
Commoner period	144	127	88.2
Colonial period	48	43	89.6

While most studies of occupational inheritance stress the term "identical occupation" of father and son, it probably has little social significance. Whether the father is a doctor of medicine and the son becomes a lawyer is not so important as whether the occupational status which the son achieves is higher, lower than or equal to that of his father. Climbing is not denoted by identical or dissimilar occupational designations, but by whether the level of occupation is identical or different in terms of social prestige, cultural status and purchasing power.

In Table IV the occupations of fathers and sons are compared. In the United States, where until 1870 over 50 per cent. of the gainfully employed were working in agriculture, where an increasing population was moving westward to occupy free land all during the eighteenth and nineteenth centuries, it is natural to expect that a large percentage of rulers would have farmer fathers. Farmers furnished more sons who became lawyers than any other occupation in which fathers were engaged, yet farmers contributed less than a third as many lawyer sons as the upper levels of occupation combined. Characteristically, therefore, rulers whose occupation is the law have been recruited from

TABLE IV

COMPARISON OF RULERS' OCCUPATIONS WITH OCCUPATIONS OF THEIR FATHERS

Occupations of rulers	No. of rulers	Number of fathers in occupations: Lawyer	Business and finance	Army officer	M.D.	Professor	Journalist	Preacher	Govern-ment official	Planter	Farmer	Clerical	Manual laborer
Lawyer	232	46	36	5	20	7	4	10	1	35	63	...	5
Business and finance	31	3	18	1	1	...	2	1	1	...	3	...	1
Army officer	5	1	...	...	...	...	...	1	...	2	1	...	...
M.D. (physician)	6	1	1	...	1	...	...	...	...	...	3	...	...
Professor	5	...	...	...	...	...	...	2	...	2	...	...	1
Journalist	15	...	3	...	1	...	5	1	...	...	3	1	1
Engineer	2	...	1	...	...	...	...	...	...	...	...	...	1
Government official	2	...	1	...	...	...	...	...	1	...	...	...	...
Planter	5	1	...	...	...	...	...	...	...	4	...	...	...
Farmer	4	...	1	1	...	...	...	...	...	...	2	...	...
Manual laborer	4	...	...	...	...	...	...	1	...	...	...	...	3
Totals	311	52	61	7	23	7	11	16	3	43	75	1	12

homes whose fathers are located in the upper levels of occupation. This is characteristic also of every upper level occupation in which rulers are engaged.

As was shown previously, the occupations in which rulers engaged were almost entirely in the upper levels of employment. This is not true of their fathers, and there is upward movement to the extent that a difference exists between the two. The amount of climbing is shown in Table V.

TABLE V

TYPE AND PERCENTAGE OF OCCUPATIONAL CLIMBING OF RULERS AS COMPARED WITH THEIR FATHERS

Type of climbing	Per cent. of climbing			
	All rulers	Modern	Commoner	Colonial
Total climbing	25.7	24.4	30.6	13.9
Climbing from medium to high levels	23.1	21.4	27.5	13.9
Climbing from low to high levels	2.6	3.0	3.1	0.0

In a fraction less than 75 per cent. of the instances rulers have been born into homes located in the upper levels, where they have had the advantages of the purchasing power and prestige adhering to such levels. Over 23 per cent. of the climbing which has taken place has been of sons whose fathers were independent farmers. In less than 3 per cent. has the climbing been accomplished by rulers who were born into manual laborers' homes. In almost every instance the rise of sons has been the result of several factors which placed the sons in the élite of gainfully employed. In part it was the natural consequence of the apprentice system which prevailed in the professions and in business. In considerable measure it was an accompaniment of the settlement of the country. A pronounced factor has been formal schooling, which has equipped sons for occupational activity higher in social prestige and income than that in which their fathers engaged.

The popular notion persists that Presidents are representative of the common people. The total amount of climbing of Presidents as compared with their fathers has been 35.4 per cent., of which 3.2 per cent. represented climbing from low occupational positions of fathers to high levels of sons, and 32.2 per cent. was movement upward from farmer fathers' status to membership of sons in the upper occupational brackets. Since 1877 nine of the thirteen Presidents have had fathers in the élite of occupations. Only one President, Herbert Hoover, has risen during this period from the home of a laboring man.

CONCLUSIONS

Perhaps the greatest qualifying factor in the race for higher status has been formal education. This factor is more important to-day than ever before in our national history, for no longer does a young man enter the professions unless he has had college or university training. For the most part, the apprentice system is gone in the professions.

Education being basic to acquiring training required of national rulers, it becomes necessary to inquire whether educational opportunities are so equally open to all that no serious discrimination exists. In a recent analysis of the enrolments in colleges and universities the writer found that children of manual laborers comprised from 6 to 23 per cent. of the student bodies in these institutions, depending upon the type of school studied. Even such a popular institution as the junior college in enlightened California has a student body whose fathers in only 24 per cent. of the cases are engaged in skilled or unskilled

labor, whereas these occupations were being followed by 44 per cent. of the gainfully employed who had children of college age. All other forms of higher education are decidedly more aristocratic than junior colleges in the composition of their student bodies.[2]

It has been popularly argued that the laboring masses are relatively unproductive of superior intelligences, which accounts for their poor representation in our institutions of higher learning, and consequently their negligible number among our national rulers. When proportionate yields of the several occupational classes are determined on any intelligence test basis, this seems to be the case, but when total population numbers are considered, approximately 80 per cent. of those who test "very superior" and "superior" intellectually are found among the skilled, semiskilled and unskilled laborers, clerical workers and agricultural hands. Yet their opportunities to secure higher education and to reach higher occupations are relatively few.

Our national rulers, whom we might reasonably expect to be fairly representative of our people, are a highly selected group chosen from those who are born into moderate circumstanced or wealthy homes, who receive high educations and who enter the peak of occupations. The qualifying barriers are insurmountable for all except a very few of our people whom fortune has especially favored. In the interest of a democracy which seeks to use to the utmost the talents of all its citizens a more equitable plan should be devised which will enable talent, wherever it is born in the social scale, to express itself fully. But before any rational planning is possible the facts concerning vertical movement in all walks of life must be ascertained. It is only with the possession of these facts that a policy of correct occupational distribution can be formulated which will achieve equality of opportunity.

[2] H. Dewey Anderson, "Whose Children Attend Junior College?" *Junior College Journal*, January, 1934.

ART IN CLOCKMAKING AND WATCHMAKING

By Dr. D. W. HERING

PROFESSOR EMERITUS OF PHYSICS; CURATOR OF THE JAMES ARTHUR COLLECTION OF CLOCKS AND WATCHES AT NEW YORK UNIVERSITY

THE making of clocks and watches demands ability of two distinct orders, science and art. The need for the former is obvious and requires no demonstration. It is inherent, since a timepiece, even a poor one, will not function without the application of science in several forms, especially mathematics, astronomy and physics, and in a high-class instrument the scientific features are technical, ingenious and often abstruse. The part that art has played is important but is incidental rather than necessary. It may be of interest to see in what ways art has manifested itself in clocks and watches. In distinction from "The Arts," which comprise various industries whose products are generally the result of some mechanical process, and which are imitative or duplicative, the "Fine Arts" are supposed to depend primarily upon intellect and imagination; they are essentially creative and productive and are more fully entitled to be regarded as art.

Art in its grand forms—architecture, painting, sculpture, music—is so imposing that it overshadows the minor forms which find expression through various industries. So prosaic sometimes are the industries and so commonplace their products that the artistic highbrow looks with contempt upon these homely efforts and denies the right of their authors to rank with the élite possessors of the soul of art. However just or unjust such an assumption may be with respect to genius—that spirit which eludes definition—there is no denying the artistic quality of many an article of manufacture, whether textile, metal, jewelry or furniture; objects of design and construction that have often been so distinctive as to make their designers famous and their designs fashionable, creating "periods," although critics in one period condemn the taste that dominated another period. Conceivably a distinction might be drawn between a timekeeper and a work of art in that the primary purpose of the former is to be of practical service, while the latter, so far as its artistic quality is concerned, has no reference to practical utility; it is essentially esthetic or emotional in motif. That is not to say that a work of art may not be useful or that a clock or a watch may not have artistic features. Presumably the ingrained artist does practice art for art's sake, but even the Michelangelos were not indifferent to the pecuniary emoluments of their product, and literary genius has only too often been forced into the drudgery of producing pot-boilers. The clockmaker has always wanted his work to look attractive, whether he had sufficiently good taste to make it so or not.

An enthusiastic mechanical genius early in his life fixed upon clockmaking and watchmaking as embodying at once the principles both of science and art; science dealing with time and its mysteries and art that went beyond mere craftsmanship. Artists of the brush or chisel, of music or literature, have a lofty disdain for the pretensions to art by workers whose efforts depend upon machinery; but even if some of them are mere pretenders the work of others has often been fine and beautiful, and with the worst of them we may as well give the devil his due. An inspection of examples of the craft may show how far some are entitled to be called art and how far and in what ways others come

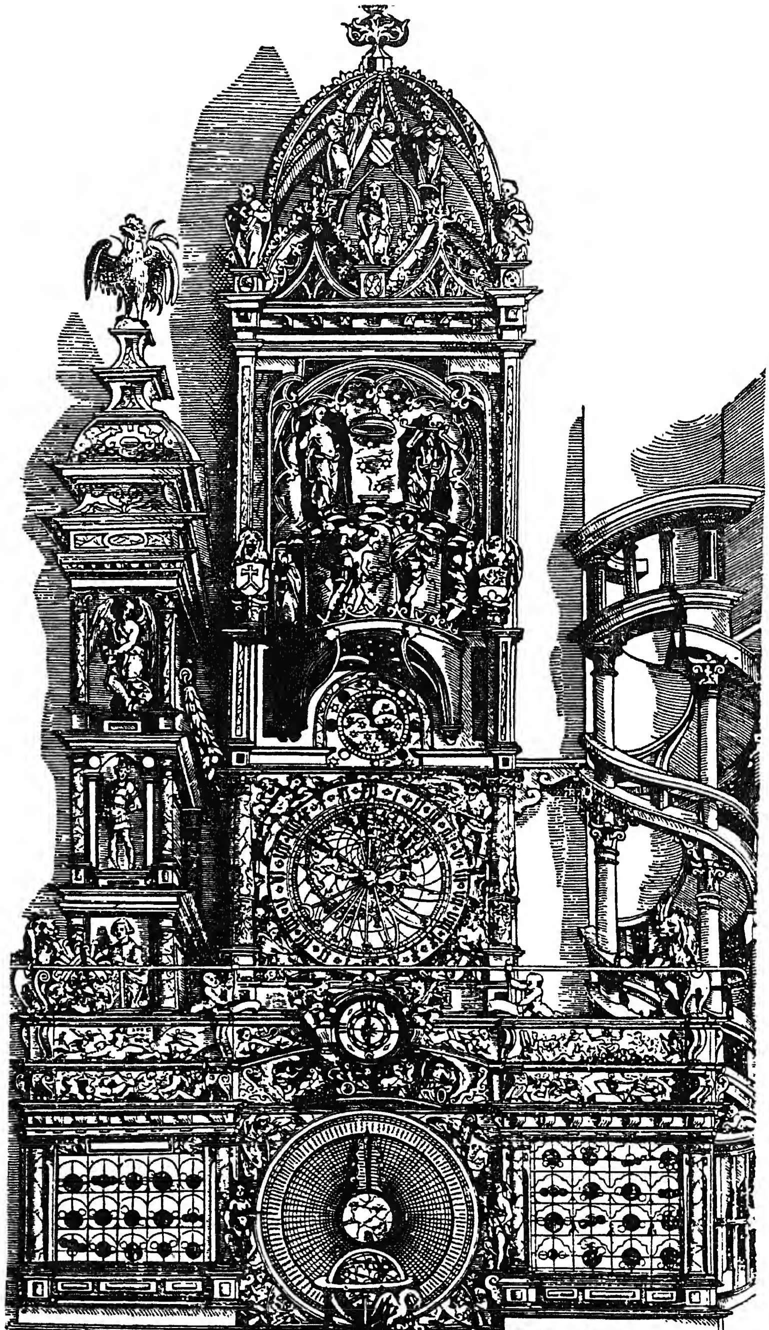


FIG. 1. THE SECOND CLOCK OF THE STRASBOURG CATHEDRAL, 1574

short. Recognizing first that the art of designing and making clocks may differ in some ways from that expended upon watches, the clocks themselves may be properly distinguished as public and domestic. The former were not said to be "made" or "constructed" but "erected" or "built," thus putting them in the class with buildings or monuments and making their art (if they had it) architectural. The term "fecit," often inscribed by makers, was generally reserved for domestic clocks. With these there seemed little opportunity for artistic effect, at least in the grand manner, although an authoritative critic, in a recent work, has commented pointedly upon the presence or the absence of artistic merit in them. While the individual clockmaker was still to be reckoned with, say especially from the middle of the eighteenth century to the middle of the nineteenth, English masters were in the lead, although the French, Swiss, German and Dutch had each their own definite style and American makers had begun to invade the field; and the same critic speaks severely of these last for the absence of art from their designs and, by implication, extols the presence of it in English output.

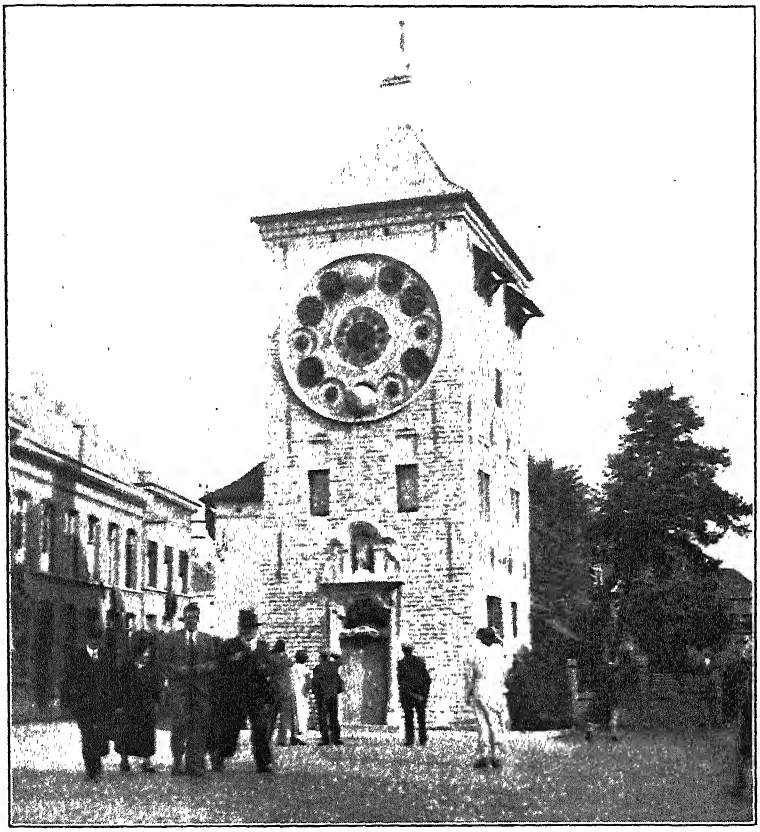


FIG. 2. ZIMMER TOWER AND CENTENARY CLOCK, LIERRE, BELGIUM
THE CLOCK OPERATES SEVENTY-THREE ASTRONOMIC AND CALENDAR DIALS. PHOTOGRAPH BY THE AUTHOR.

Early mechanical clocks were of massive construction; they were erected for a permanent stay in some tower, cathedral or town hall that was often of unquestionable architectural merit, and the

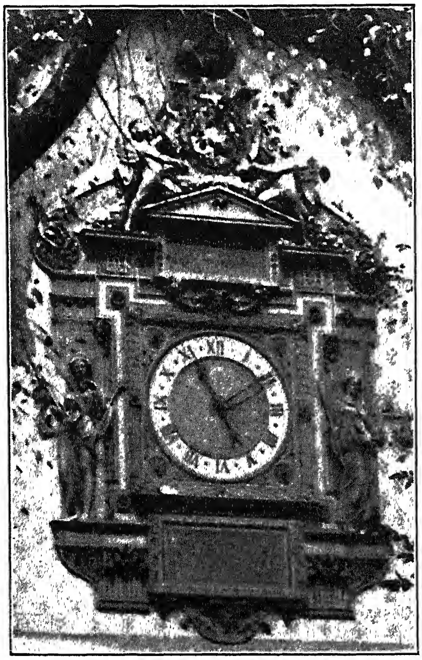


FIG. 3. DIAL OF THE CLOCK IN THE PALAIS DE JUSTICE, PARIS. IT BEARS THE DATES 1685, 1852 AND 1909 WHEN IT HAS UNDERGONE REPARATION. PHOTOGRAPH BY THE AUTHOR.

clock was designed to be in artistic harmony with the building, of which it was an important feature. In that character the clock of the Strasbourg cathedral, dating from 1354, has long been famous and has been the subject of much elaborate description and the cynosure of thousands of admirers. Sixty feet high and twenty-five feet wide at the base, it was an imposing structure and if the clock and the cathedral could be viewed apart from each other it would take no very critical eye to see that this clock belongs to that cathedral. It is perhaps the most bewritten of all clocks. Alfred Ungerer says ("Les Horologes Astronomiques"), "There have been published concerning this clock about four hundred works and descriptions more or less detailed, in prose, in verse, and in the form of working models (*'pièces de theâtre'*)." Like most early public clocks this has been several times renewed and somewhat remodeled, but in the main has preserved its original form. The first clock operated from 1354 to about 1520; the second from 1574 to 1786; and the third from 1842 to the present time. During the intervening intervals of forty or fifty years it was too dilapidated for use. Fig. 1 shows the clock in its second and most elaborate form.

Hardly less celebrated is the great clock of Rouen, dating from 1389. The Strasbourg Cathedral clock is noted for its automata, like that of St. Sebaldus in Nuremberg, that of Berne, and many others; the Rouen clock especially for its beauty of design and decoration. With the revival of learning following the Renaissance the clock came to be re-

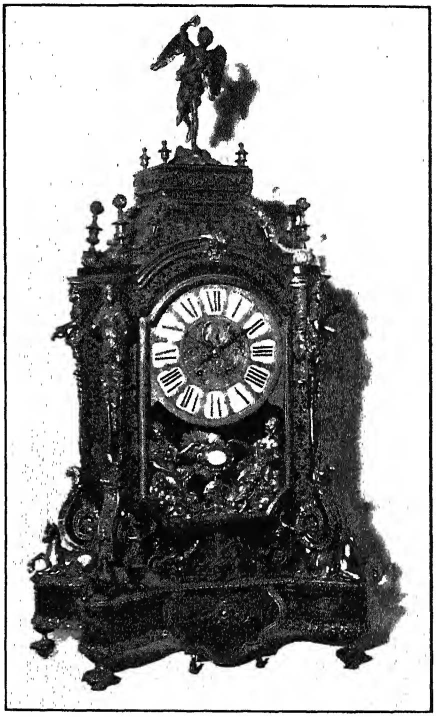


FIG. 4. LOUIS XIV CLOCK BY BALTAZAR, ABOUT 1700. THIS TIMEPIECE AS WELL AS THOSE SHOWN IN FIGS. 5–7 AND 9–18 FORM PART OF THE JAMES ARTHUR COLLECTION OF CLOCKS AND WATCHES AT NEW YORK UNIVERSITY.

garded as an important part of municipal equipment and a source of pride to the citizens, and civic spirit impelled the different cities to vie with one another in the effort to produce the finest example. Mr. G. H. Baillie, a most competent authority on this subject, enumerates 223 public clocks erected prior to 1600—ninety-three in the fourteenth century, sixty-five in the fifteenth, and seventy-five in the sixteenth; and these were succeeded by many more in the seventeenth and eighteenth centuries. Practically every city of any considerable size in Europe had one and some had several. They were usually placed upon the City Hall or in cathedral spires or towers, where they could be seen and heard at a great distance.

As a rule the movement of a public clock is mounted on a substantial frame within the building and only the dial is

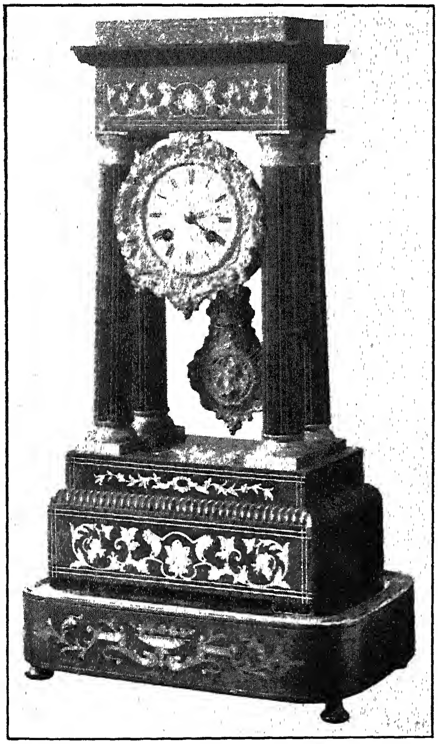


Fig. 5. Dutch hood clock, about 1700.

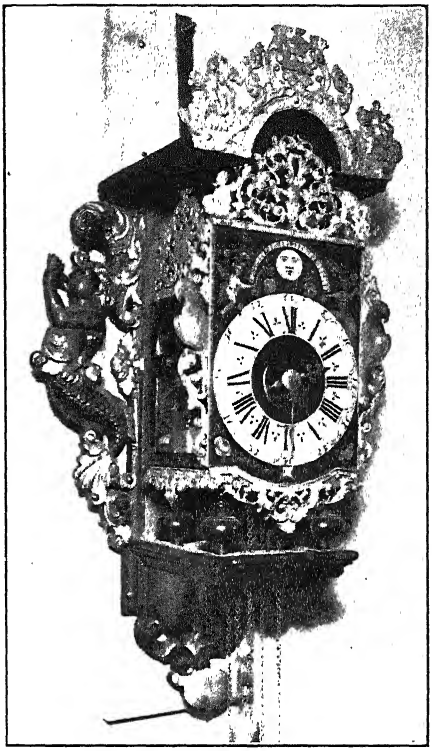


Fig. 6. Clock in Empire style, first quarter of the 19th century.

open to view; it is upon the dial, in such cases, that ornamentation is lavished. One of the most celebrated of clocks was that built for King Charles V of France by Henry De Vick, 1370–1378. This was placed in the Palais de Justice in Paris. The original clock-work has entirely disappeared, but the dial, several times renewed, is still in place on the eastern façade of the Palais de Justice at the northeastern corner. Its present appearance, with overhanging foliage, is shown in Fig. 3. The dial ring is five feet in diameter; the extreme height of the dial is nearly twenty feet and width about twelve feet.

Marking the time of day is only a small part of the duty of an astronomical clock; some are intricate and multitudinous in their performances and show many astronomical positions, move-

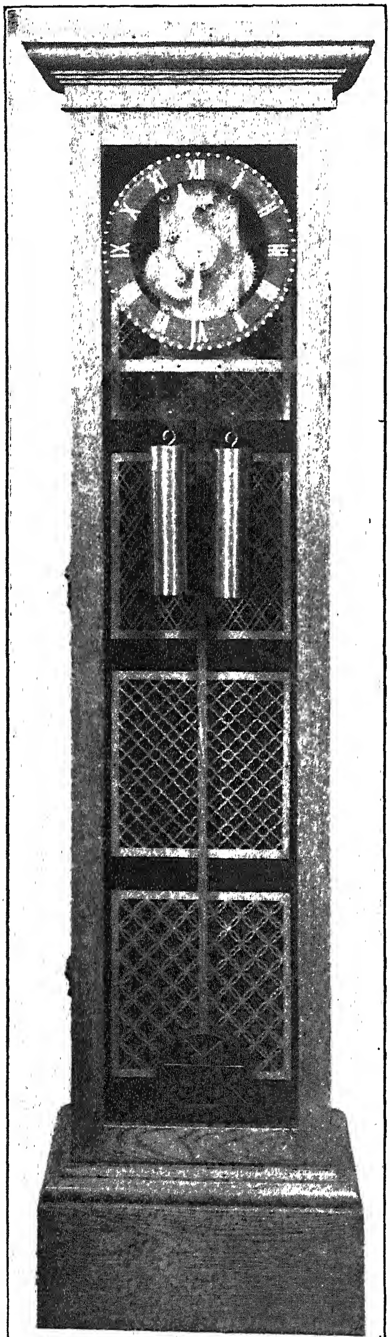


FIG. 7. LONG CASE CLOCK BY JAMES ARTHUR, 1902.

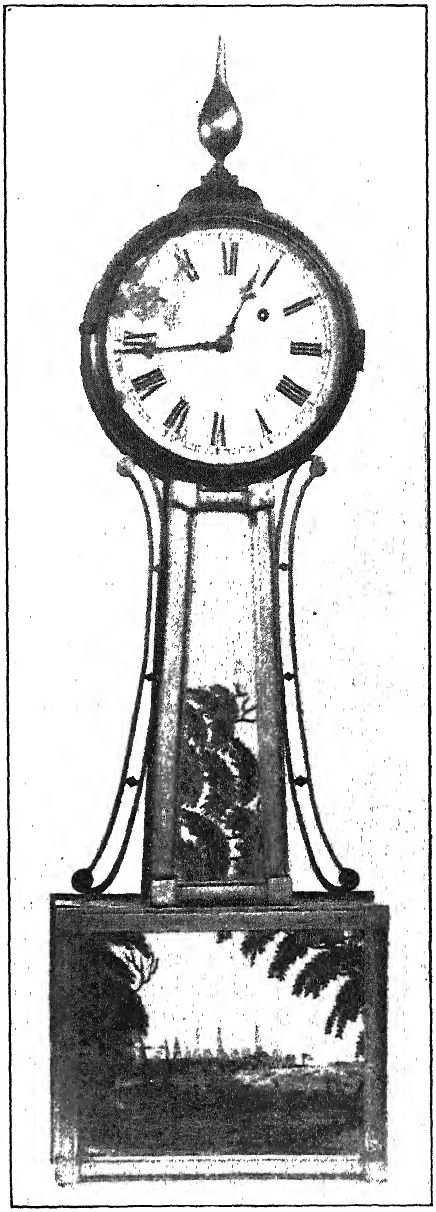
ments and phenomena; the position of the sun (or the earth) in the zodiac, the change of seasons, the phases of the moon, the day of the week or of the month, and many other features, each of which had its own separate dial; and for each dial there was apt to be a costume appropriate to the phenomenon—sometimes allegorical sculpturing—calling for an attempt at artistic treatment. The hour circle is usually divided into twenty-four parts (or hours), which are numbered from one to twenty-four, or in two successive series of one to twelve.

This multiplicity of dials and complexity of operation reached a climax in 1930, when Alfred Zimmer, of Lierre, Belgium, clockmaker to the Royal Court of Belgium, completed a "Centenary Clock" which he donated in 1931 to the city of Lierre on the occasion of the hundredth anniversary of Belgium's independence. The elaborate timepiece was supplemented by numerous movements constituting an "Astronomic Studio," and the combination was installed in a three-story stone tower reconstructed by the city for that purpose. The principal dial consists of a large central circle showing Greenwich standard time; this is encircled by twelve other dials, each of which indicates some feature of astronomy or the calendar. In all there are seventy-three dials. A replica is to be exhibited at the coming World's Exposition to be given in Brussels in 1935.

Naturally tower clocks do not find their way into private collections, but their merits as also their defects are matters of record. They are still in demand, but as they are not objects of mass production each one is built by special contract with a "company." The hands traverse the dial and the hours or chimes are rung by electric motors controlled from a master clock in a lower room of the building. Science

governs their action and their design, and art plays a subordinate rôle. The clock of the Colgate Company, in Jersey City, has the largest dial in the world, sixty-one feet in diameter, and has many exceptional features, but no one could accuse it of being architecturally beautiful. That on the Paramount Building in New York City is more pleasing to the eye and would probably be more approved as an example of art.

With clocks (not watches) it is almost exclusively the case or mounting that is the subject of artistic treatment, and this was often, perhaps most frequently, the work of a designer whose name has been lost, while that of the maker of the mechanism, which is the clock proper, has survived. They were not usually the same person and sometimes were so completely dissociated that portable clocks at first were often supplied without a case. This, if desired, was made by a cabinet maker, often in a locality remote from that in which the original clock was made and at a later or, possibly, an earlier date. To this custom, however, there were important exceptions. Royalty had "makers to the King," who enjoyed royal patronage in various lines and supposedly derived advantage in business from the right to affix such title to their names. A clockmaker and a cabinetmaker "to the King" were among those who were thus favored. Technically, clock cases are furniture, and as furniture went in fashions or "periods" the clock cases followed the fashion and what was highly approved in one period was not acceptable in another, unless there was a revival. Specimens of an earlier period came to be valued later as antiques. A notable example of this was the so-called "Buhl work." André Charles Boulle (1642–1732), cabinet maker to the king under Louis XIV, introduced a very ornate style in which the body of a piece of furniture was veneered with a layer of tortoise shell that was inlaid with metal or mother of pearl cut out in elaborate patterns. It was costly but became exceedingly popu-



Courtesy of Dr. N. B. Van Etten, New York.
FIG. 8. BANJO CLOCK, ABOUT 1825.

lar with persons of wealth or the nobility. It was taken up in other countries than France and the name was Germanized into "Buhl," which is the form now

most generally used. Though now out of vogue, specimens are to be found in museums and are highly prized. A good example is shown in Fig. 4. This clock was made about 1700 by Baltazar of Paris, who was clockmaker to the king.

In his satirical poem on "Contentment" Oliver Wendell Holmes wrote:

> Wealth's wasteful tricks I will not learn,
> Nor ape the glittering upstart fool:—
> Shall not carved tables serve my turn;
> But all must be of buhl?

The taste for the *rococo* which prevailed in France in the late seventeenth and early eighteenth centuries was reflected in the work of other countries. In Holland especially, stimulated by the ingenuity of the great physicist Christian Huygens, clock-making became prominent. Their most admired clocks of this period were florid displays of gold and color. Fig. 5 shows an example of their "hood" clocks having an ornamental case under a decorative canopy.

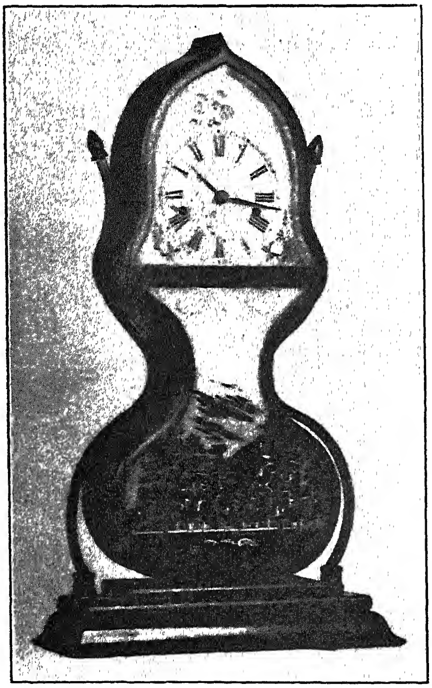


FIG. 9. ACORN CLOCK, ABOUT 1825.

The styles of Louis XIV, Louis XV and Louis XVI (1643–1793) were florid, in a steady decrescendo until, during the Empire (1804–1815), they became much simpler; using, in costumes, the flowing lines and graceful curves of classical Grecian drapery, furniture became severely simple in design and clocks followed the new fashion unless designed by an independent and unconventional thinker. Fig. 6 is a clock in Empire style contrasting with the Louis XIV of Fig. 4.

The late Mr. James Arthur, of Brooklyn, N. Y., in the course of more than forty years gathered a large and varied collection of clocks and watches from many different countries and of dates covering a period of three hundred years. He was not a professional clockmaker or watchmaker, but he was a skilful mechanic and an enthusiastic inventor. He constructed numerous clocks of his own design, among them several illustrated by Fig. 7. This, in the natural color of the wood, with straight lines has for its only ornamentation the fretwork lining the back which, with the mechanism, is plainly in view through the glass front and sides of the case. Lacking altogether the elegant marquetry of Boulle, and the gaudy and "baroque" carving of the Dutch and Friesland clocks, it is given here as an extreme contrast to those shown in Figs. 4 and 5, and in its proportions and good taste is more artistic, notwithstanding the fact that the major purpose of its maker was to show special features of the clock as a time-keeping machine.

A handsome volume which appeared recently, recounting Connecticut clockmakers of the eighteenth century with numerous illustrations of their clocks, drew comments from an English authority disparaging to the American efforts on account of their commonplace designs and ungraceful proportions. Within a

quarter of the succeeding century, however, *i.e.*, between 1825 and 1850, the making of clocks in America had grown into a great industry, and competing inventors and manufacurers were put to it to devise cases that would have some distinctive form or character. Among the best known and most popular forms were the "Banjo" by the Willards (Simon and Aaron) of Massachusetts, the "Pillar and Scroll Top" by Eli Terry, the "Looking-glass Case" by Chauncey Jerome, and the "Acorn" by the Forestville Manufacturing Company; the three last named were produced in Connecticut. The Banjo and Acorn are shown in Figs. 8 and 9.

Simon Willard patented his "improved timepiece" (banjo) in 1802; it was meant to be hung up against a wall or pillar. There would seem to be no particular reason why a clock should be shaped like a banjo, but a reasonably close-fitting round head was suitable to contain the movement; for the slender swinging pendulum no enclosure could be more appropriate than the tapering waist; and the pendulum bob, three or four inches in diameter and requiring a path six or eight inches in length, naturally suggested the horizontal box below. The inventor probably had no intention to copy a banjo for the design of his clock, but the semblance of that instrument into which the construction grew no doubt tickled his fancy—as it did that of his customers. Professor W. I. Milham in "Time and Timekeepers" says that the Willards never used the name "banjo" for these clocks.

The Terry clock, patented in 1814, was born of the desire for a clock with a wooden case to stand upon a shelf instead of to hang up against a wall, and the style adopted by Eli Terry met that purpose in the simplest possible form and gained immediate popularity.

But why should a clock be made to look like an acorn? Unintentionally

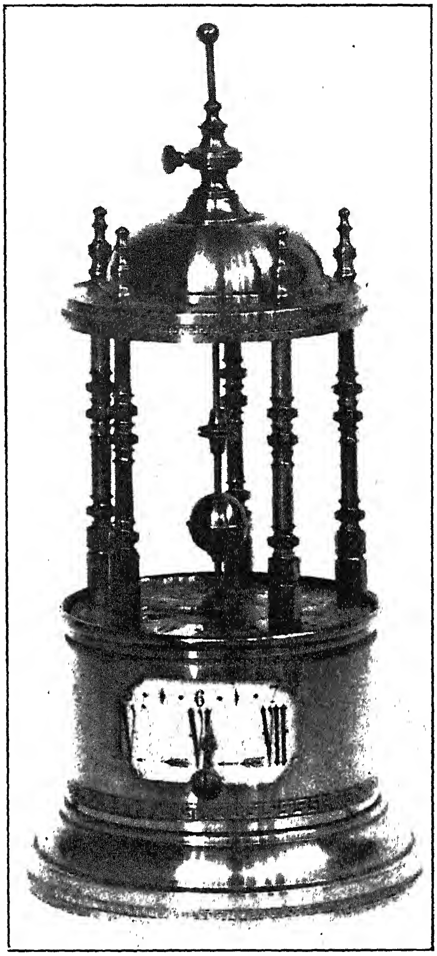


Fig. 10. Small clock with conical pendulum and cylindrical rotating dial.

perhaps the realm of musical instruments had been invaded by Simon Willard with a startling popularity as a result; then the cabinet form of case had been appropriated by Eli Terry and modified by Chauncey Jerome by the insertion of a looking-glass; what remained for competitors better than the natural product of a forest tree? Competition became a free-for-all contest of gladiators in the arena: Simon Willard dealt his rivals a severe blow with the banjo: Eli Terry countered with the pillar and scroll top case; Chauncey Jerome came in with a looking-glass;

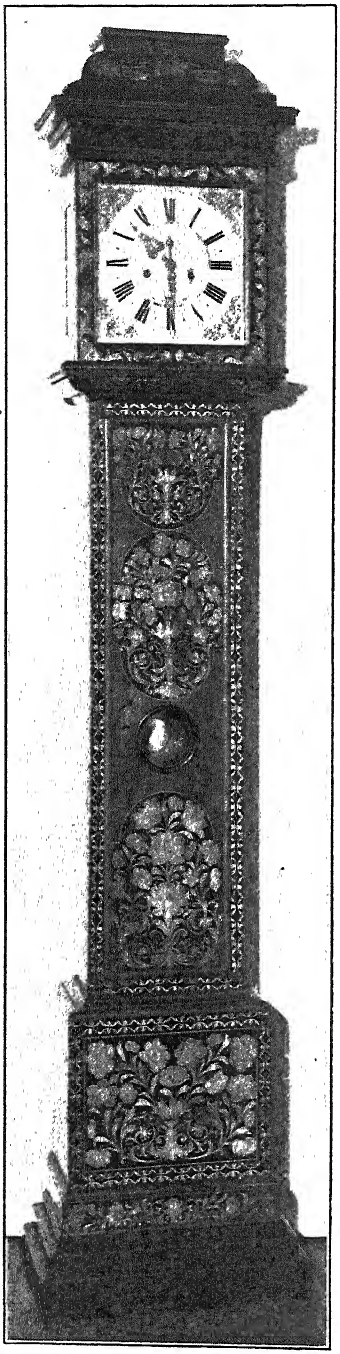


FIG. 11. CLOCK CASE OF WALNUT, INLAID WITH WHITE WOOD AND EBONY, 1695.

the Forestville Manufacturing Company bombarded them with acorns; and all these designs were pirated by other makers. Among early American clockmakers there was none too much regard for rights of priority, and plagiarism was sometimes pretty high handed. These clocks were all good timepieces for their day and with their methods and material of construction, but as works of fine art not to be taken very seriously.

It should go without saying that a structure should accord in design and appearance with the purpose it is to serve. That is an end to be desired, but one which architects do not always succeed in attaining, and we have imposing libraries that look like mausoleums or the Pantheon and are ill adapted to the needs of readers, students and librarians; theaters that suggest churches or picture galleries; and railroad passenger stations that look grand but confuse and impede rather than help the traveler or simplify his perplexities; and the same discord is found in many public clocks. Unless the clock is part of a cathedral it is hard to see why it should look like one, yet that was a favorite pattern with early clockmakers. It was carried to extremes in what is regarded by some competent judges to be the oldest clock now in existence, that of Philip the Good, Duke of Burgundy, accounted as of about 1430. The most plausible inference is that the maker devoted his efforts to producing a work of art and dismissed the idea of utility as something not to be included in an artistic conception. Its timekeeping quality was less important to him than the artistic.

The small clock shown in Fig. 10, only seven inches in height, immediately calls to mind the beautiful little Temple of Diana in the gardens of the Villa Borghese, Rome.

Considering the distortions and mon-

strosities that are often displayed in so-called art exhibitions it is hardly worth while to hold the clockmaker strictly to account if he departs from its canons.

In the Middle Ages and up to within a century ago the interests of tradesmen both in commerce and manufactures were subject to regulations of "guilds" which were organized for many occupations. Before any guild of clockmakers or watchmakers existed the scattered mechanics who made or built clocks were metal workers and were most often members of a blacksmiths' guild. Sometimes they were expert blacksmiths to whom clockmaking was an avocation rather than a vocation. In Scotland metal workers were incorporated in various guilds as "hammermen," that of Edinburgh dating from 1483, but clockmakers and watchmakers were not admitted to membership until 1646. The idea of taking a watch or a clock to a blacksmith to be repaired seems fantastic to us now and we do not think of a smith of any kind as an artist, but our estimate calls for some revision when we recollect that Quentin Matsys, a renowned painter, first arose to fame by his artistry in ironwork. Still, Quentin Matsys are not numerous. Incidentally, it is interesting to note that such masters as Quentin Matsys and Albrecht Dürer were given to mathematical formalism that would be repudiated by freehand painters. The former fairly geometrized his subjects by arranging them in a scheme of mathematical lines and figures, and the latter followed a precise system of proportions—an anthropometric formula—to depict character or temperament in his men and women; and so did Charles Le Brun, court painter to King Louis XIV, and probably many others.

It is upon domestic rather than upon public clocks that art has been called into service. The long case ("Grandfather Clock") has been made the sub-

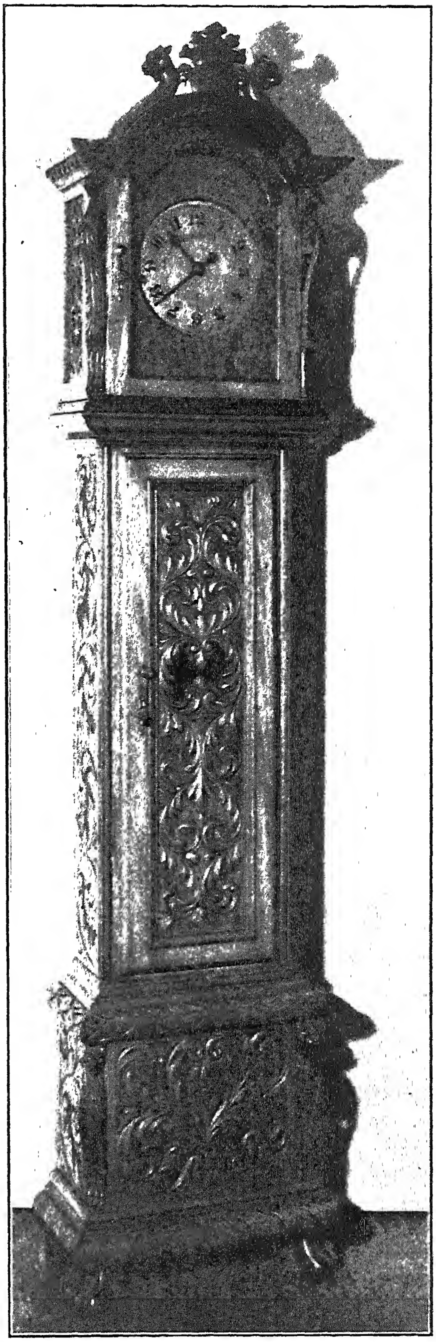


FIG. 12. CLOCK CASE OF MAHOGANY, RICHLY CARVED, MODERN.

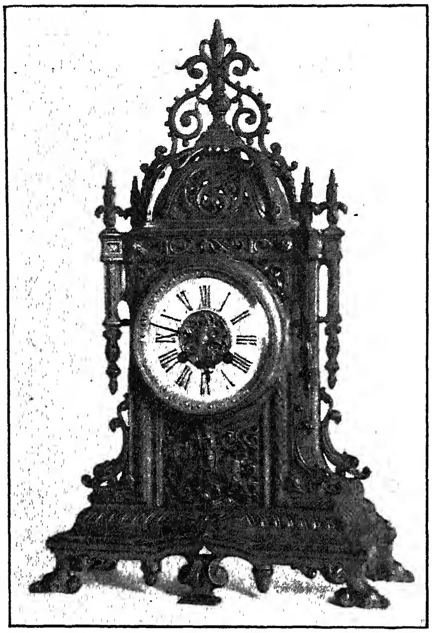


FIG. 13. BRONZE CLOCK BY JAPY FRÉRES, ABOUT 1810.

ject of decoration especially by inlay work, as in Fig. 11 or by wood carving as in Fig. 12.

Before hand work was displaced by machines, designs could be varied without seriously affecting the cost of production. The greatest variation then meant a change of style, while minor changes could be made in individual pieces. At one time it was the fashion to mount the clock upon some animal, the elephant being the favorite; again the clock cases, especially small ones, often of marble, onyx or alabaster, were surmounted or flanked by sculptured figures of cupids or mythological creatures or statuettes of bronze or brass. Fig. 14 shows a handsome French modern clock on a mahogany base. The metal mounting is reddish brass, highly ornate, with portions of its surface finished in colored enamel. The pendulum, a Cupid, swings forward and back instead of right and left.

In the making of metal cases Frederic Japy of Beaumont began the departure from art for its own sake, with watches in 1776 and with clocks in 1810, by an innovation in their manufacture which might be characterized either as standardization, commercialization or degradation, but which grew out of artistic capabilities in the introducer. This was the use of machines to manufacture in large numbers cases of clocks or watches from his original *ébauches*—a sort of mass production of cases that were alike in the rough, but which were to be finished by hand and in which there was enough leeway for modification of the design to give a separate individuality to each one. Fig. 13 is an example. As much as a hundred years ago the dispute raged between the disciple of art and the philistine as to whether the spiritual perversion is not more than justified by the material benefit to society.

About the year 1600 A. D. the Japanese began to use mechanical clocks for keeping time according to their system of horology, which they had borrowed from the Chinese many years earlier and which differed in many respects from

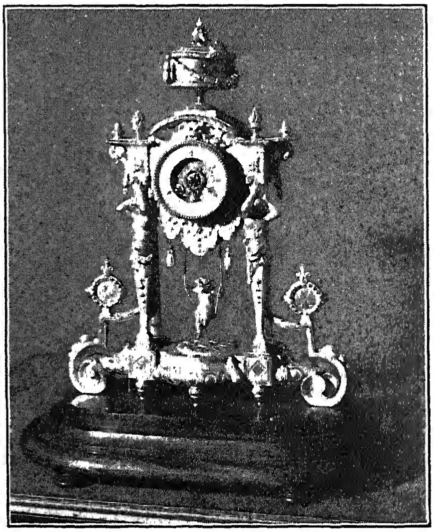


FIG. 14. ORNATE FRENCH CLOCK, MODERN.

that of western peoples. The Japanese retained this system until 1873, and during the period from 1600 to that date, nearly three centuries, they used clocks which they adapted to their peculiar method of time reckoning. They were great copyists and they copied the mechanical construction and lantern form of early Dutch clocks, but the style, coloring and finish reflected the oriental tone of art. It was the custom of Japanese artisans to dwell upon minutiae of detail. Moreover, whether a part of the construction was to be conspicuous or not, it had to be ornamented like all the rest. In Fig. 15 the brass case on the pyramidal base contains the mechanism which is like that of the European "foliot" clocks of the sixteenth century. Elaborate engraving covers this entire case and is supposed to be pleasing to the eye. The weights are hidden within the wooden base and are visible only when this is open, as in the illustration, but these weights, particularly the dumb-bell, are covered with the same profusion of carved tracery. In some of their earliest clocks the case of iron is inlaid with beautiful designs in silver and copper—the damascening of the armorer's art in the Middle Ages. The clock here shown is five feet high, including a hood. To the Japanese, short in stature and, when not standing, seated on the floor, this was a "tall" clock.

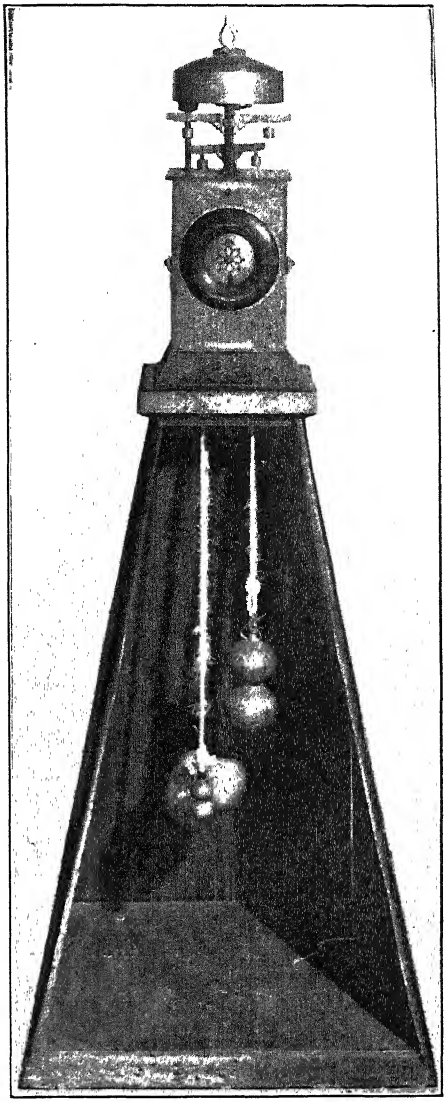


FIG. 15. JAPANESE CLOCK ON PYRAMIDAL BASE.

It is when an industry is in process of development that attempts are made to cater to popular taste and also to educate it, as seen strikingly during the last half century or less in the progress of electrical invention, the automobile and radio; and in a machine age it is in such lines of growth that budding artistic skill comes into flower; attractive designs are constantly in demand and the demands become more exacting with every advance. Students in art schools or schools of design, ambitious of achieving some great work eventually, seek opportunity to apply their talent by designing models of cars, furniture, household appliances, patterns for wall papers or for textiles, or what not, in the employ of manufacturing companies before they attain the dignity of an atelier of their own, or solicit and fill private or public commissions. Manufacturers of clocks and watches are on the alert for fine designs of cases as well as for improvement in the movements. An agent so potent, so adaptable and all-in-

sinuating as electricity was certain to be enlisted in clockmaking, and although electric clocks have been produced for many years they had not very encouraging success before the general distribution of electricity from central stations opened the way for better electric clocks. Within the last few years two types have been rapidly developed: one, an electrically controlled "balance" clock; the other, the "telechron" or synchronized alternate current motor. The idea caught the public fancy, and the simplicity of the mechanism, especially of

FIG. 16. WATCH WITH PAINTED ENAMEL BACK, ENCIRCLED WITH BRILLIANTS. BY JULIEN LE ROY, ABOUT 1730.

the latter form, made it possible to construct them cheaply. As a consequence, competition was keener to obtain fine designs of mounting than to make a fine piece of machinery. Unfortunately, there are companies operating that are less concerned about producing a real work of art than about making something bizarre in appearance yet cheap enough to be within the reach of every family, and the country is deluged with millions of trashy clocks, made to sell. The purchaser has a choice of many different models, the display room is gaudy, and if the clock will only go over the salesman's counter it doesn't matter much about its going afterwards. A prospectus of a prominent manufacturing company, making good clocks, recently showed about a dozen forms of small electric clocks, most of them odd in shape or color, one like a tombstone, and none noticeably artistic. But, with all the chaff there is a fair admixture of good grain. One leading company lays stress upon the fact that their models are "spirited designs from Europe's foremost casemakers," and they are unquestionably handsome. Some are revivals of early designs and if any rank among artists may be accorded to Thomas Chippendale, George Heppelwhite, Thomas Sheraton, Duncan Phyfe and others who produced distinctive furniture, many modern clocks may be considered artistic, since their makers used (or abused) the styles of these masters.

Passing from the artistry of the clock to that of the watch is in some sense like passing from the grand canvasses of Paul Veronese or Tintoretto or the murals of Puvis de Chavannes or Blashfield, La Farge, Abbey or Sargent to the exquisite gems of Hans Memling or the warm delicacy of a Claude Lorraine. (The Post Office Department did not shrink from the attempt to put the Grand Canyon on a postage stamp!) And whereas in clocks artistic feeling found expression in forms appropriate to furniture, in watches it necessarily took on the character of jewelry, since the purpose of a watch, other than to keep time, was to adorn the person of its wearer. This was more markedly so in early watches, which were worn as much for decorative effect as for telling the time; so the art here was that of the goldsmith instead of the cabinet maker. The work of the goldsmith, silversmith and jeweler is among the oldest examples of art and is still recognized as art, but the manufacture of watches, like that of clocks, has become subordinate to that of

the artisan except in the finest specimens. It was different before individualism was submerged under mass production. For everyday purposes the utilitarian does outweigh the artistic.

A rota of distinguished clockmakers and watchmakers would include names as familiar to artisans of that craft and their patrons as the best known among painters, sculptors, musicians or any other class of creative genius. If a seventeenth-century Dutch citizen alluded to his "Frans Hals" there was no need to explain that he meant a painting; if an Englishman of the same period alluded to his "Tompion" he was as readily understood to mean his watch—equally a masterpiece of art; and the claim of such makers to the rank of artist rests upon the facts that they were creative and that their work was often intellectual more than manual, since it involved a good deal of horological science.

One of the most celebrated collectors of watches, Carl Marfels, acquired several collections in succession. The first and second of these collections became the property of the late J. Pierpont Morgan; the third was Mr. Marfels's crowning achievement. It consisted of only twelve watches, but these were of the most exquisite character, and the most important criteria in gauging the merit of the pieces were: (1) artistic quality; (2) unimpaired state of preservation; (3) rarity of the objects. Note that "artistic quality" is put first. In a beautifully illustrated description of the third collection by M. Loeske, as originally printed in the *Deutsche Uhrmacher-Zeitung*, concerning "the artistic treatment of cases, dials and cocks" the writer says, "it is indeed not saying too much that this artistic treatment . . . can not be surpassed . . . these old masters of their art will as little ever be surpassed as the great Greek sculptors, of the great painters of the 16th and

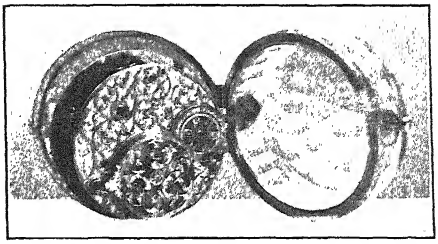


FIG. 17. RARE WATCH IN CRYSTAL CASE, SEVENTEENTH CENTURY.

17th centuries, the architects of the Renaissance, or the old classic musical composers." Further, he says, "it is much to be regretted that of all the remarkable watches we find in our museums and private collections, only the name of the master who has made the watch work may still be known, but very seldom that of the goldsmith who has created the highly artistic and concerning the value of the object the much more important case.

Opportunity for developing artistic ideas is necessarily limited in an object so small as a watch; nevertheless, the ideas were developed with considerable variety, and both skill and taste were expended not only upon the watch cases and dials but also upon the framework

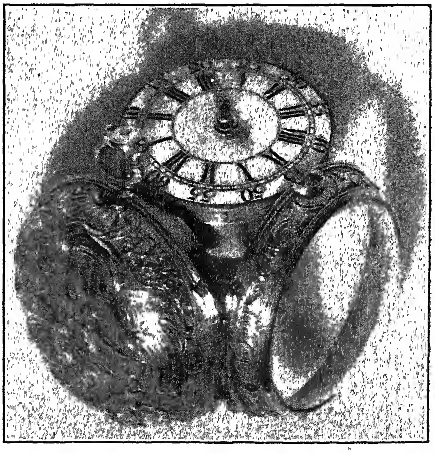


FIG. 18. REPEATING WATCH WITH GOLD *repoussée;* CASE BY QUARE.

that supported the wheels. At first the watch was altogether metal work and was decorated by carving or engraving; from an earlier period painting on enamel was carried to a high stage of excellence, and artists in that line rose to eminence; about 1635 enamel dials began to be used on watches, and this style of art was carried over to the finish of watches, both face and back. As its beauty depends on the coloring it can not be satisfactorily shown in a black and white picture. Their elegance was sometimes enhanced by a setting of precious stones, and fine specimens of that art, rivalling the artistic claims of other paintings, now command thousands of dollars. This mode of decoration continued, but with gradual decadence, through the eighteenth century.

Styles come and go in jewelry as they do in furniture and just as designs of clocks varied with styles of furniture, so taste in watches varied with that in jewelry. The better grade of work has usually been in gold and silver; in later years platinum has figured somewhat, though not largely, and gold and precious stones have generally been used most effectively. Before the watch was so cheapened that everybody could have one a fine specimen was a luxury that appealed to the vanity of the wearer. It became a *sine qua non* in fashionable circles, and an "exquisite" among dandies was not content with mere gold. The watch was suspended from a chatelaine, and both were richly bejeweled, but even that was not enough for insatiate vanity, and in the latter part of the sixteenth century the work of the goldsmith was further beautified by that of the lapidary, and watch cases were made of single crystals of quartz. Clear and highly polished they rivaled even the diamond in beauty. Fig. 17 shows a fine specimen.

The watch in Fig. 17 has a crystal case that is a round, deep cup with a lid, also of rock crystal. The pendant knob and ring are of gold, and the lid is held on by a gold band. The entire case, including the lid, is smooth on the inside but finished on the outer surface with polished triangular facets, more than two hundred and fifty in number. The movement, finished largely in gold, is no less artistic. Through the transparent case is seen the entire movement, richly decorated in gold—the realization of a watchmaker's dream. It is by J. Mercier, of Paris, about 1695. This style of watch was especially favored in France and Germany during the seventeenth century. In another style of decoration, *repoussée,* the case was stamped from within, producing in relief a pattern of sculpture or a copy of some painting. It is illustrated in Fig. 18.

Watches as well as clocks often take the form of oddities sometimes grotesque, not always pleasing (as, for example, a skull or some distorted figure), and often lacking esthetic features that might entitle them to be regarded as fine art. In the world war the watch was called into service as never before in military operations, and the practise of wearing it on the wrist became common. The same practise was taken up by civilians and the *beau monde* soon called for patterns of taste and beauty, so the wrist watch has been produced in styles both grotesque and arabesque.

The scientific character of the watch has been developed more than the artistic, but at no time has a maker of first rank or a company producing first-class timepieces failed to employ high artistic ability to provide suitable cases in which to mount the movements; and few industrial arts employ as great diversity of talent as does the making of clocks and watches, where subjects range from large structures of stone or wood, through intermediate sizes and forms, to miniatures and gems.

THE NATURE OF CANCER

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CANCER, like life, still baffles the scientist who searches for the deeper secrets of its nature. Perhaps this is because cancer is very definitely a form of life. But to say that we know nothing of the nature of cancer is to take too pessimistic a view. When the isolated known facts concerning this disease are brought together they not only form a surprisingly large mass, but when pieced together they form a remarkably complete pattern from which one may judge its nature with some degree of accuracy.

Cancer is not now believed to be the result of infection with any known *type* of microorganism. The reasons for this belief are numerous. Every known type of microorganism — filterable viruses, bacteria, yeasts, fungi, protozoa and even metazoa—have been charged with the crime of inducing cancer. But no single species of parasite has been isolated from cancer with any degree of constancy; and none of those which have been isolated have unquestionably induced well-authenticated cancer. The only exceptions to the last statement are the filterable virus of chicken sarcoma and the infectious genital "sarcoma" of dogs. But these are strictly limited to the respective species of animal.

All infectious diseases have a period of incubation during which the invading microorganism is increasing to sufficient numbers in the body to induce symptoms. It is true that in some chronic infectious diseases, such as tuberculosis and leprosy, the incubation period is not clearly recognizable. In cancer no incubation period exists in the sense in which it was defined above. In experimental tar cancer, and probably also in spontaneous cancer, there is a relatively long latent period. But this delay in development of the disease is not due to the slow growth of any microorganism in the body. Furthermore most of the agents which will induce experimental cancer—such as tar, arsenic, shale oil, soot — have more or less germicidal power.

In infectious diseases some degree of immunity develops and can be demonstrated by the presence of immune bodies in the serum. No such immunity to cancer has been demonstrated. It is even claimed by Freund and Kaminer that normal human serum will cause the lysis of human cancer cells, while serum from a cancer patient will not.

Cancer does not behave like an infectious disease. When pathogenic microorganisms enter the tissues of the body many types of cells—polymorphonuclear leucocytes, lymphocytes, plasma cells, histiocytes, capillary endothelium and fibroblasts—take part in the processes of resistance to the invasion of the microorganisms and the repair of the damage which they do. In cancer one type of cell not only predominates, but the connective tissue stroma and blood vessels within the tumor merely furnish passive support or nutrition to the dominant cells. Neither the tissues in which the cancer is growing nor the body as a whole offers any effective resistance to the growth of the cancer.

If cancer is not an infectious disease, two corollaries naturally follow. First, cancer is not transmissible. There is no danger of a healthy person's "catching"

the disease, no matter how closely he may be associated with the patient. Second, there is no stigma or disgrace attached to cancer. It is not a "blood disease" in the sense in which that term is used by laymen. The feeling of shame which many cancer patients have is one of the most serious obstacles in the way of successful treatment of the disease, for it leads to delay and delay is fatal.

Even the layman recognizes that cancer is a growth. But growth is a normal attribute of living tissues. To appreciate the peculiarities and to understand the nature of cancerous growth it is necessary to contrast it with normal growth as it occurs in the developing embryo and in the regeneration and repair of injured tissues.

Every human being begins life as a single cell, the fertilized ovum. This cell divides into two, these into four, and this process of cell division at first proceeds at a rate that no cancer can equal. This rapid multiplication of cells proceeds in an orderly fashion and develops a definite pattern. The particular pattern developed is the result of many factors.

(1) *Heredity.* Each species of animal has its own pattern of growth. In the development of the human embryo certain faults in reproducing the normal pattern may occur. Some of these faults, such as Cohnheim's embryonic rests, may be a factor in the later occurrence of cancer.

(2) *Orientation.* Very early in the process of growth the mass of cells, possibly the original fertilized ovum, becomes orientated with reference to itself into cephalad and caudad, anterior and posterior, the right and left, parts.

(3) *Formation of embryonic layers.* With the infolding of the hollow sphere of cells the ectoderm, entoderm, and mesoderm originate.

(4) *Differentiation.* From these several embryonic layers the various organs of the body differentiate in accordance with the special pattern of the species.

(5) *Subordination of the organs.* The size of each organ is subordinated to the size and needs of the organism as a whole. No organ exceeds its allotted volume.

(6) *Transference of energy of growth into energy of function.* In its earlier stages the chief need of the embryo is the development of its organs with their potentialities of later function. As these organs approach or reach their requisite size the rate of growth slows down. The enormous energy previously used up in growth is now available for the performance of function.

Throughout normal embryonic growth the enormous rate of increase in the number of cells remains within the limits of its special pattern. The rate of growth gradually decelerates until at birth it is proceeding at a leisurely pace, which is progressively retarded after birth until it ceases or at least becomes balanced with the loss of cells due to wear and tear, when the individual reaches his full stature.

The transference of energy of growth into energy of function is not an irreversible change. When tissue is destroyed, the adjacent cells regain their power of regeneration in inverse proportion to their degree of differentiation and specialization. These cells revert to a more embryonic type but still maintain the quality of obedience to the law of growth observed by embryonic cells in general. Since the connective tissues are the least differentiated, they take the dominant rôle in repair with the ultimate production of scar tissue. But in the process of repair the growing cells reproduce the patterns of their respective tissues; keep within the limits of the needs of the occasion; do not invade healthy surrounding tissues, nor produce metastases; do not exceed the

amount necessary to adequate replacement of the cells originally destroyed; progressively diminish their rate of growth as the goal of complete repair is approached; and cease to regenerate once the destroyed tissue has been replaced and the damage repaired. The growth of repair is not continuous, and the newly formed cells differentiate and mature. Occasionally the production of scar tissue may be too luxuriant, giving rise to the keloid not infrequently seen in the Negro race. If the process of repair occurs in a region which is also the seat of chronic inflammation, any epithelium which is involved may undergo such marked hyperplasia and even metaplasia as to resemble a malignant growth. But when the inflammation subsides, the epithelial hyperplasia and metaplasia cease and most of the excess proliferated epithelium disappears or becomes walled off by connective tissue.

Cancer begins in one place from a single cell or from a small group of cells. In its early stages it is, therefore, a local disease. But the growth of cancer cells differs in almost every respect from the normal growth of cells in the developing embryo and in the process of regeneration and repair. Although the cancer cell is derived from the cells of the body it is quite unlike any other cell of the body in any stage of its development. Cancer cells have undergone dedifferentiation, but they have not become embryonic cells. Their rate of growth is essentially continuous without the normal retardation as some goal is approached, for they have no goal; they do not reproduce any pattern, or do so only imperfectly; their growth is not oriented, but proceeds irregularly in all directions; they acquire a new habit of growth, become autonomous and are not controlled by the law of the needs of the body as a whole; they force their way into surrounding healthy tissues and destroy them; they invade blood and lymph vessels and are carried to distant parts of the body where they form new foci of cancer growth; their energy of growth is never transformed into the energy of function, because they perform no useful purpose in the body; they acquire a new habit of respiration, anaerobic glycolysis, and produce large quantities of lactic acid even in the presence of an abundant supply of oxygen, a process which neither embryonic nor adult or mature cells exhibit when the supply of oxygen is adequate. These characteristics mark the cancer cells as something quite different from any normal cells of the body at any stage of its development.

What causes this deep-seated, fundamental change in one or more normal cells of the body to transform them from useful units in the economy of the body into the racketeering elements that they become, is unknown. Neither do we know what causes the original fertilized ovum to proliferate at such an amazing rate. But to say that nothing is known concerning the cause of cancer is untrue. Quite enough is known concerning the agencies and influences that will induce cancer to justify efforts directed toward its prevention. The present status of the cancer problem can best be introduced by a brief historical survey of our knowledge of this disease.

Cancer is a very old disease. Fossil remains of dinosaurs and of pithecanthropus erectus show evidence of tumors of bone. The Ebers papyrus (1500 B. C.) has a section on tumors. Even in the days of Hippocrates patients placed votive statuettes in the temples in the hope of being cured of disease and at least one such clay model of an ulcerating carcinoma of the breast is still in existence. Physicians have therefore recognized cancer for more than 3,000 years. But it was not until the invention of the microscope and espe-

cially the discovery of a method of sectioning and staining tissues that the true nature of cancer was revealed and a means provided for its accurate differentiation from other diseases which resemble it in gross appearance.

The first phase of the development of modern knowledge of cancer—its microscopic diagnosis—began with Virchow. This advance added relatively little to the fundamental problem of the etiology and essential nature of cancer, but the method still has everyday practical application in every accredited hospital. The limitations of this method were soon recognized and scientists turned from this narrow field of observation to the broader and more stimulating but treacherous field of theory. The last third of the nineteenth century saw the birth of Cohnheim's theory of embryonic rests, of Weigert's theory of tissue balance and numerous other attempts to solve the problem merely by "giving thought" to it—a method which has not added one cubit to stature of our knowledge of cancer.

A new impetus was given to the study of cancer when Jensen, in 1903, reported the transplantation of a tumor from one rat to another and described adequately the conditions essential to successful transplantation. The yield in knowledge from this procedure was disappointing. The chief contributions from this source were: (1) that it is the transplanted tumor cells that grow in the host animal; (2) that the tissues of the host take no part in the growth except to furnish a supporting framework or stroma; (3) that some animals possess a high degree of resistance to transplanted cancer which is unable to grow in them; (4) that the presence of one growing transplanted tumor renders the animal immune to a second transplantation of the same tumor; and (5) that transplanted tumors do not ordinarily metastasize but may be made to do so by massage and other rough handling.

Before the depression due to disappointment with the yield of knowledge from Jensen's contribution had reached serious proportions, Fibiger reported the finding of carcinoma in the stomach of a rat infested with a nematode worm. Learning that the larvae from this parasite occurred in cockroaches he searched for months through the City of Copenhagen for these vermin infested with the desired nematode larvae. He finally found an abundant supply in an old sugar mill in the outskirts of the city, only to have the mill burn down immediately thereafter. But this method of experimental production was too uncertain and was soon replaced by a more reliable and simple method.

About the middle of the nineteenth century, Virchow had insisted that chronic irritation was an important factor in the causation of carcinoma. By 1914, numerous types of occupational cancer were known to follow prolonged, relatively mild irritation by chemical and physical agents; such as, "chimney sweep's cancer," due to irritating effect of soot collected in the folds of the skin of the scrotum; cancer of the lung in the workers in the cobalt mines of Schneeberg, Germany; "mule spinner's cancer," due to the action of lubricating oils on the skin; cancer among shale workers, probably due to paraffine; cancer of the bladder in aniline workers; cancer developing in chronic ulcers of the skin among the early workers with x-rays; cancer of the cheek in chewers of the betel nut; and "Kangre cancer" on the front of the abdomen of inhabitants of the Vale of Cashmere, who carry a small stove in a wicker basket under their garments.

In 1914 Yamagiwa and Itchikawa described a reliable and effective means of producing cancer experimentally by the simple procedure of painting the skin of an animal with gas-house tar. The world war prevented an immediate capitalization on this important dis-

covery. Since 1918 the number of papers published on experimental tar cancer exceeds one thousand. Many principles have been developed that have practical application in human cancer.

(1) There are marked individual and species variations in susceptibility to the carcinogenic action of tar. The different degrees of susceptibility of individuals of the same species is probably related to heredity. For Lynch found that the incidence of cancer in a strain of mice with a definite cancerous heredity could be increased from 37.04 per cent., which was normal for the strain, to 85 per cent. by painting the skin with tar. But tar will induce cancer in a smaller, but still considerable, percentage of animals without this hereditary tendency. The effect of tar on different species is interesting. Mice are most susceptible to its carcinogenic action, rabbits somewhat less so, while dogs appear to be quite immune. It is almost or quite impossible to produce carcinoma of the skin of a rat with tar, but sarcoma of the subcutaneous tissues can be induced.

(2) For the successful production of tar cancer the degree of stimulation is important. If the irritation of the tar is too severe only simple ulceration usually results; if it is not strong enough, only papillary hyperplasia of the surface epithelium occurs. This necessity for a rather fine adjustment of the degree of irritation is a possible explanation of the failure of many forms of chronic irritation to produce cancer in man.

(3) Cancer rarely develops in mice or rabbits in less than 5 months after the beginning of tar painting, and tar cancer will develop in young animals just as readily as in old ones. These facts have led to a reconsideration of the relation of age to human cancer. Before these facts were known many pages had been written and many theories advanced to account for the more frequent occurrence of carcinoma in persons past forty years of age. The general view was that the passing of the years resulted in disturbances in function or in nutrition of the cells, or in an alteration in the balanced resistance between epithelium and connective tissue which, in some way, prepared the way for carcinoma. Five or more months in the life of a mouse is the equivalent of from 9 to 15 years in the life of a man. Hence a modern explanation of the more frequent occurrence of cancer after the age of 40 is that chronic irritations are not likely to develop before the thirtieth year, and the 9 to 15 years necessary for them to induce cancer would place the onset of the disease in the 5th decade or later.

(4) When a fairly large area of skin is painted with tar, cancer develops in one spot only. If this first cancerous spot is removed another cancer will develop in another part of the painted area. The presence of one cancerous growth in the tarred area exercises a restraining influence on the other epithelial cells which have been equally irritated. This probably is one of the reasons for the fact that spontaneous cancer is unifocal in origin, regardless of the extent of the region irritated. The occurrence of a new but not recurring second cancer in a person who has previously had such a tumor removed is probably an indication that the first tumor was completely eradicated. Carcinoma of the large bowel sometimes develops in the base of one of multiple benign polyps. Only when such a cancer is removed one of the remaining polyps may give rise to a second carcinoma.

(5) Tar cancers metastasize and can be transplanted, if not too badly infected. Hence they behave in all essential respects like spontaneous cancers. For this reason experimental tar

cancer in lower animals has furnished much valuable information applicable to the disease in man.

The second important factor in the causation of cancer is heredity. Dr. Maud Slye in a study of the relation of heredity to cancer in more than 100,000 mice, all of which were descendants of some 7 or 8 original individuals, has concluded that not only a tendency to cancer in general, but also a tendency to organ specificity for cancer are inherited as a Mendelian recessive character. C. C. Little and others have also shown a definite relation between heredity and cancer in mice. These investigators do not agree in the interpretation of their results on the basis of genetics, but they all agree on the observed fact that spontaneous cancer occurs with much greater frequency in mice that have a cancerous heredity.

The fact that these experiments on mice involved a degree of inbreeding never present in human heredity renders it doubtful whether the conclusions derived from them apply with equal cogency to human cancer. Cancer statistics are notoriously unreliable. Careful analysis of as reliable statistics as are available by C. C. Little and others indicate that the incidence of cancer is higher among persons one or both of whose parents died of cancer than among persons without this hereditary background. Cancer of the uterus is rare among Jewish women, and of the breast among the women of Japan. In each instance there is almost complete racial purity due to prejudice against any form of miscegenation. The total death rate from cancer is remarkably alike in all the countries of Europe. But the distribution of cancer among the organs of the body shows a marked variation in different nations. This may be the result of an inherited organ specificity for cancer, kept active by the preponderance of matings between persons of the same nationality. There are, therefore, certain reasonably well-established facts which indicate that heredity is a factor of importance in the occurrence of cancer in man. But an hereditary tendency toward cancer in mice and men behaves as a Mendelian recessive with all the biological implications of that term.

Summary

(1) Cancer is not an infectious disease, is not transmissible and carries no stigma of which the patient need be ashamed.

(2) Cancer cells are derived from the cells of the patient's own body. They undergo some deep-seated change that renders them fundamentally unlike any other cells of the body in any stage of its development. They acquire a new habit of growth, an altered relation to the neighboring cells and to the body as a whole and an abnormal method of respiration.

(3) The most important agencies or influences that induce cancer are heredity and chronic irritation. Heredity furnishes cells some of which are sufficiently unstable that prolonged irritation induces a complete alteration in the nature and habits of one or more especially susceptible cells and they become cancerous. Most cancers appear to be the result of the combined action of heredity and chronic irritation.

ALGAE OF BIZARRE ABODES

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ALGAE grow in many and diverse habitats. They are found in fresh and in salt water, in mountain torrents and quiet pools, on the surface of the soil and at considerable depths, on ice and on snow, from 300 feet below sea level to alpine heights, and from the equator to the poles. Perhaps it should not be surprising that algae live and reproduce in a multiplicity of environments, although the characteristics of protoplasm that permit survival under such extremes are well-nigh inexplicable.

Algae are also more or less intimately associated with numerous other living organisms, both plant and animal. An alga, in addition to the various habitats just enumerated, may live in or on another plant; or it may live in or on an animal. A short list of such animate "hosts" includes bacteria, fungi, liverworts, cycads, magnolias, oaks, tea plants, water fleas, worms, sponges, cockroaches, guinea pigs, ducks and chickens, bears, horses, cattle, sheep, goats, hogs, and even you and me. Truly there are agencies even outside politics that make for "strange bedfellows."

Many species of algae are free-floating and constitute the so-called phytoplankton, or plankton algae. The aquatic forms, exclusive of the plankton, may be roughly termed sedentary or attached. Such plants may grow on almost any conceivable object or substrate: a reed or a rush or some other seed plant, an alga, an animal, a rock or a stone, a dock or a boat or a ship, a shell, the bottom of a lake or the bed of a stream, a log or a stick. The algae may be attached by special hold-fast cells or by stalks and other forms of jelly-like material.

Every one has seen long strands of *Cladophora* in running water; bright green coatings of *Ulothrix* and *Stigeoclonium* on stones of lake margins; slippery accumulations of *Fucus* on rocky seashores; and blue-green blobs of *Rivularia* on sticks and logs in quiet water. Some forms, like *Cladophora* and *Rhizoclonium,* are perennials and may be seen nearly any time of the year. Most of the attached algae, however, are abundant only at certain definite and rather short periods of time: *Ulothrix* in early spring and *Rivularia* in late summer, for examples.

The particular object to which attachment is made appears to bear little or no relation to any specific alga. The greatest factor is undoubtedly proximity to the algae at the time of spore formation. Rough surfaces with small interstices are better sources of lodgment than smooth ones. In fact, the germinating spores of some algae, like *Oedogonium* or *Bulbochaete,* make rather imperfect holdfasts or none at all in smooth glass vessels. Discarded and untenanted snail shells of the rougher sort furnish ideal lodgment for *Cladophora* and *Stigeoclonium* spores which upon germination and growth give the appearance of "life anew" to such gastropodous castaways. Many algae, particularly the larger marine forms, grow on stones and rocks and are called lithophytes.

Partially or nearly submerged stones, sticks and logs may be covered by adhesions of gelatinous material containing in particular blue-greens and diatoms. *Nostoc, Cylindrospermum* and *Oscillatoria* may lie very close to the surface of the substrate; *Gomphonema* and *Navicula* may produce ever-lengthening stalks of mucus that supports the algal cells at some distance from the rock or stone.

Many of the algae discussed above

become planktonic when the warm water dissolves the supporting mucilage. Great quantities of diatoms loosened at one time by a sudden increase in water temperature often form "pulses" in streams. Similar "blooms" develop in lakes and ponds with prodigious rapidity after germination of spores in the bottom mud and rise of the young plants to the surface of the water.

Algae attached to other plants and growing there are referred to as epiphytes. They should not be confused with the colorless parasites which depend upon their hosts for sustenance. Among seed plants we are familiar with epiphytic mistletoe, air plants and tropical orchids. Many kinds of algae, such as *Aphanochaete, Bulbochaete, Stipitococcus* or *Cocconeis,* may grow upon other algae like *Vaucheria, Cladophora* or *Mougeotia.* In aquatic situations the leaf blades, leaf sheaths and stems of practically all macrophytes serve as objects of attachment for algae. Cattails and some smartweeds rarely have abundant algal epiphytes, and it is quite possible that there are degrees of epiphytism among different plants.

It is well known that peripheral parts of most algae are quite gelatinous. The slipperiness and sliminess of filaments of *Spirogyra;* the colonial matrix of *Volvox, Microcystis* and *Tetraspora;* and the enveloping sheaths of *Lyngbya* and *Scytonema* are familiar to all. These mucilaginous coats are excellent habitats for bacteria. In most aquatic forms the association is probably quite accidental, and during vegetative growth the algae and bacteria may bear no relation except as space partners. In soil algae, however, the two members may be mutually helpful in nitrogen fixation. Mass accumulations of algae are doubtless hastened in their decomposition by associated bacteria of decay. Bacteria in the sheaths and coats of many algae are so nearly ever-present that it is practically impossible to grow absolutely pure cultures of some species. Czurda (University of Prague) has been able to get filaments even of such algae as *Spirogyra* free from bacteria by frequent shakings of vigorously growing plants in distilled water.

The non-aquatic epiphyte is perhaps more common to most of us. *Pleurococcus* (*Protococcus*) has been known for years as a name for the greenish incrustation on many tree trunks. It usually occurs on the less lighted or sometimes leeward side of the tree, and rarely grows in latitudes with an annual rainfall of less than twenty inches. It is more common on some trees than others, and this may be due to differences in roughness of bark, humidity of the air or age of the tree. *Trentepohlia* and *Prasiola* are also conspicuous members of what one might call aerial algae: those growing on barks of trees as well as on woodwork, masonry, stones and cliffs not submerged. Aerial algae are thought to require an atmosphere of rather high humidity, even though the area may be extremely localized.

Pleurococcus seems actually to require very little water and so thrives in air of ordinary moisture content. It is characteristic of such algae that they are able to withstand long periods of desiccation without any appreciable injury to the vegetative cells. When moisture becomes available, the plants show rapid increase in greenness and vegetative activity. Apparently the cells are practically impermeable to water during these droughts, and Fritsch suggests that they are then in a state of "paralysis." Their protoplasts contain no large vacuoles, and the protoplasm survives without the customary water supply. Whatever the explanation of such remarkable resistance to arefaction, it is quite evident that something besides visible structural modification is fundamental.

In discussing aerial algae one finds it difficult exactly to delimit and classify. Many observers in tropical regions have been impressed with the prodigious

abundance of aerial and subaerial algae growing on every stone, tree trunk, wall and roof, as well as on the ground. It has even been facetiously remarked that algae are found on some of the more sedentary brethren among the natives, but the writer has not verified such observation. It is true that in regions of excessive rainfall algal mats may be seen growing on almost any conceivable object. The algae are usually dark green rather than light green in color, and the blue-greens loom large in the composition of the flora. Colors vary all the way from bright blue to dark blue-green or nearly black. *Trentepohlia* along with a few other genera of green algae is very abundant, but it is usually some shade of orange-red unless growing in shady places.

Not easily separable from the above are the algae which grow on the leaves of other plants: the so-called epiphyllous algae. They do not differ materially from bark epiphytes and other aerial forms. They apparently suffer little from desiccation because of the high humidity to which they are nearly continuously subjected. Some forms grow in intense light, while others are found in considerable shade. The number of species of epiphyllous algae is probably not large because the same plant may occur on almost innumerable hosts. The number of individuals, however, is doubtless equal or perhaps superior to that of any other group of plants in the tropics, with the exception of the bacteria.

There are various degrees of epiphyllism from the casual epiphyte to the real parasite. Most epiphyllous forms are disk-like, subcuticular or merely place epiphytes. There are, however, a few genera that seem to be restricted to localized leaf areas. One of the most interesting is Palm's *Stomatochroon*[1] which grows in the stomatal cavity of the leaf and is apparently anchored there by a lobed holdfast. The alga consists of a few cells, enters the cavity through the stoma and is found on a wide variety of host plants, both cultivated and wild. It is perhaps the most widely distributed epiphyllous alga of the tropics. Rare in virgin forests of dense shade, it grows on open, sunny weed and bush vegetation of waste and fallow land, on low-growing secondary jungle, on pastures and on garden and orchard plants. The aerial parts of *Stomatochroon* are golden yellow to intense purple or brown, due to a richness of hematochrome in the cells. The basal cell is curiously enough vivid green and devoid of hematochrome.

Passage through the stomata in the case of *Stomatochroon* seems to be merely a matter of growth. It has been reported that amoeboid cells are responsible for the entry into leaves of species of *Chlorochytrium* and *Synchytrium*. *Cephaleuros* gains adit through cuticular and epidermal lesions by zoospores. When the algae are merely surface epiphytes, no apparent injury occurs to the host. Complete covering of areas of the leaf perhaps prevents the penetration of rays of light of certain wave-lengths, but the data are insufficient to draw any inferences. It is when such algae are subcuticular and subepidermal that pathogenicity becomes evident.

Stomatochroon may cause coppery or yellowish-red discolorations of the leaves of the host. True parasitism, or at least pathogenicity, however, is shown by the nearly ubiquitous *Cephaleuros* of tropical and subtropical regions. It grows in Florida, according to Wolf,[2] on grapefruit, sweet lemon, Cuban shaddock, tea, magnolia, loquat, avocado, Spanish jasmine, tangerine, temple orange, cinnamon, fringe tree, shining privet, bay and coral berry. The leaves are usually the parts infected, although the alga may occur on both twigs and fruits. It is sufficiently important in

[1] *Arkiv. f. Bot.*, 25 (A, 16): 1–16, 1934.

[2] *Jour. Elisha Mitchell Sci. Soc.*, 45 (2): 187–205, 1930.

India on tea to be locally known as "red rust."

Cephaleuros normally causes velvety reddish-brown to orange colored cushion-like patches. If the epidermis is smooth, it may be found on both sides of the leaf; if the leaf is hairy on the lower surface, the alga appears on the upper side. It may be purely superficial, it may grow between the cuticle and the epidermis, or it may extend between adjacent epidermal cells into the chlorenchyma. The vegetative portions of the plant then may be strictly endophytic.

On the magnolia such infection is not noticeable till autumn when the leaves are about five months old. The thalli enlarge during the winter, and just prior to the rainy season—eight months after infection—both stalked and sessile sporangia appear. The plant continues to grow, and both sporangia and zoospores are produced throughout the summer, thus spreading the infection. Water and mineral salts are taken from the host by the *Cephaleuros* thalli. Leaf cells adjacent to the alga die without modification in most plants, but in a few, cork formation is initiated. The algal parasite is usually controlled by defoliation, by fungicides and by the cultivation of vigorous plants.

Some groups of algae live almost entirely within other plants and are known as endophytes. Most of them are perhaps merely space-endophytes; that is, occupying the intercellular cavities only. Species of *Entocladia* may grow within the wall layers of other algae, like *Rhizoclonium*. A species of *Chlorochytrium* inhabits duckweeds, hornwort, elodea and some mosses; an *Anabaena* lives in *Azolla;* and a *Nostoc* is found inside the thalli of the liverwort *Anthoceros*. Another species of *Nostoc* grows in the root tubercles of a cycad.

A most interesting group of algae, made up of blue-greens and greens, belongs to the algal constituents of lichens. A lichen is generally considered to be a mutual association of an alga and a fungus, perhaps symbiotic, perhaps not. The fact that one of the associates is holophytic, while the other is not, led to the early conclusion that the two are mutually dependent and beneficial: the alga furnishing carbohydrates through photosynthesis and the fungus offering protection and an added water supply. Perhaps the most remarkable thing about lichens is their ability to withstand extreme desiccation.

Most of the algal constituents of lichens are not aquatic and when free from the fungus grow in moist and shady places as epiphytes or aerial forms on stones and walls and tree trunks. The fungi are largely Ascomycetes.

Algae may also be epizoic. Common examples are *Synedra* on copepods, *Characiopsis* on rotifers and *Characium* on certain crustacea. One species of *Characiopsis,* for example, is often found only on the tail of a small crustacean (*Branchipus*), while another and related epiphyte may be confined to the forward appendages of the same animal. This is certainly a case of ecological definitiveness with a vengeance. Algae are found, in addition, on protozoa, amphipods, water fleas, fishes and turtles.

In summer one can easily get a sizable collection of the attached *Basicladia* (freshwater *Chaetomorpha*) by catching turtles conveniently carrying on their backs firmly anchored tufts of the green filaments. In fact *Basicladia* is one of the few algae that may be identified at a distance, "on the go" and by the "company it keeps." Several species of blue-greens, reds and greens are associated with sponges; in some cases this relationship seems to be symbiotic and will be mentioned later.

Perhaps the strangest algae of all are the endozoic forms. Man has long known that his digestive tract, as well as that of many another animal, contains a regular menagerie of bacteria and protozoa—organisms sometimes annoying and destructive but usually

harmless and perhaps even necessary to comfort and gastronomic happiness. It is only recently, however, that the algae have been found as a part of this strange assembly. Animals aquatic and terrestrial, vertebrate as well as invertebrate, great and small, are now thought to be hosts to certain species of algae, not only in their stomachic and intestinal tracts but even sometimes in the body cavity itself.

The earliest known endozoic algae were probably the "Zoochlorellae" found growing in apparently symbiotic relationship with infusoria (*Paramecium, Stentor*) and especially the green *Hydra*. *Chlorella* occurs in the cells of *Hydra viridis; Carteria* is associated with the worm *Convoluta;* and numerous species belonging to such genera as *Gongrosira, Spongocladia, Struvea, Thamnoclonium, Aphanocapsa, Phormidium* and *Lyngbya* are intimately associated with sponges. A species of *Aphanocapsa* (*A. raspaigellae*) occurs in the cells of sponges growing at depths of from 10 to 25 meters. *Chlorochytrium* is reported to grow in the skin of carp.

It was just about a century ago that Valentin and Farre noted blue-green-like algae from the intestine of the human species. Most of the work on endozoic algae, particularly of vertebrates, has been done, however, during the last two decades.[3] The hosts are numerous. The algae, though apparently strictly parasitic or saprophytic within the animal digestive tract, may become holophytic when removed to a lighted environment. It has been occasionally objected that these internal inhabitants are merely chance visitors from food eaten by the host. The evidence seems clear, however, that actual attachment is made with the intestinal wall and the algae live and grow endozoically for considerable periods of time.

A partial listing may suffice to show the ramifications of the ecological propensities of vertebrate-inhabiting algae. *Oscillospira* has been reported from guinea pigs, tadpoles and deer; *Simonsiella* from man, horse, cow, pig, goat, sheep and fowl; *Alysiella* (which by the way looks more like a filamentous diatom than a blue-green) from the pharynx of a hen and from the intestine of horse, pig, sheep and goats; *Anabaeniolum* from guinea pig, man and the rabbit-like rodent, agouti. It should be noted that for the present at least all such endozoic algae are classified with the blue-greens.

The tables may be turned in this queer relationship when the alga becomes host and the animal becomes epiphytic. Vorticellae are very numerous on the blue-green *Anabaena* at certain stages in its life history. Species of rotifers grow within the colonies of *Volvox* and *Coelosphaerium* and inside the cells of *Vaucheria* and *Cladophora*. Many fungal parasites, particularly the Chytrids, infest *Spirogyra, Oedogonium, Mougeotia* and numerous other algae.

When one tries to explain the habits and behavior of one's fellow man, he is often driven to mutter that there is no accounting for tastes. It is equally difficult, on the basis of our present knowledge, to account with any adequacy for the various associations in which algae grow. Some habitats seem natural and call for very little comment; others appear unusually heterodox and bizarre. It is doubtful if any other group of organisms on earth live and grow in more diversified and numerous environments than do the algae.

[3] *Annales de parasitologie humaine et comparée (Paris)* 1: 75–89, 113–123, 1923.

THE PROPER FUNCTION OF PSYCHO-TECHNOLOGY

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DESPITE the importance of the field and the number of journals and textbooks devoted to the subject, applied psychology—or better psychotechnology—has received so far no very searching analysis of its function. The philosophical and the experimental psychologists have probably, through aversion or envy, ignored the field; the practitioners have been so interested in trying to harvest the fruits of their enterprises that they have, chameleon-like, adopted the approach of hard-headed practical men, and have avoided any close scrutiny of their subject. One guesses they feel they must "play the game." This consists in selling their services to some concern and doing work for that business, or in writing books for public and school consumption that exemplify, in style as well as in content, all the principles and mannerisms of a "selling-yourself" psychology.[1]

The present paper attempts an analysis of psychotechnology and offers a statement of its proper function and problems.

(1) *Science and technology.* What we call the scientific approach to problems arose from its use and extension in the solution of practical problems. Histories of the various sciences show that many advances were made in the course of the solution of daily problems. The scientific approach has spread, due no doubt to the greater success in control its methods attain than do the rival systems of superstition and ritual.

Although many learned men try to slur over the distinctions between science and technology, others have pointed out what seem to be adequate grounds of contrast. While it may be true that the distinctions have been made for the ulterior purpose of defending the scientist's own pet interests as subjects for research against the pressure to get immediate practical results, the distinctions none the less may be quite valid. The fact that men in universities need fortifications about the fields of their research against the inroads of the legislators, administrators and others who would cut off the sources of supplies certainly does not imply that the bulwarks are illusory.

Science and technology, it has been pointed out, are not to be distinguished on the basis of their subject-matter, since the material is common to both; nor in terms of method, since both employ the methods of observation, of experimentation.[2] One might facetiously say that necessity was the mother, and the experimental method the father of the twins,

[1] See, for example, E. T. Webb and J. J. B. Morgan, "Strategy in Handling People," Garden City Publishing Company, Garden City, 1930; G. W. Crane, "Psychology Applied," Northwestern University Press, 1932. Older examples of the content, but without so much stress upon the ingratiating style, may be found in H. D. Kitson, "The Mind of the Buyer," Macmillan, 1921; E. J. Swift, "Business Power through Psychology," Scribner's, 1925; A. J. Snow, "Effective Selling," Shaw, 1929; the style is best exemplified in the many books written by W. B. Pitkin.

[2] A thorough analysis of the distinctions between science and technology, together with comprehensive quotations of the opinions of eminent scientists may be found in E. B. Titchener, "Systematic Psychology: Prolegommena." Macmillan, 1929.

science and technology. The budding occurred, to continue the analogy, when part of the embryonic matrix set out after "knowledge-in-general," while the remainder continued to pursue "knowledge-in-particular" about practical, useful affairs. The distinction is one, then, that has arisen in the modern history of science, and turns out to be nothing more than a difference in the goals, the objectives, the points of view. The scientific man in the university is typically not concerned with particular workaday problems, but with general principles and knowledge. The scientific man in the world of production and distribution of goods must be concerned with the particular problem of how to do something.

Although the difference between a scientist and a technologist may at the origin be so seemingly trivial as an attitude, many striking contrasts develop from this early branching. The man of science is disinterested, impersonal; he is willing to follow the data of his problem no matter where it may lead. He must be willing to forego any interest in the outcome for fear such an interest might bias the results. His aim is to describe and understand nature. As a critical scientist he recognizes that, after all, "explanations" fit only the common-sense approach, and that strictly his laws turn out to be a systematic description of what may be observed under specified circumstances.

In contrast, the technologist has specific interests in the outcome. His problem consists in getting certain results: to build a bridge, to cure a patient. Interesting problems may arise, but can not be followed lest they provide unprofitable distractions. Very often such side projects might even interfere with the success of the project. Psychiatrists often report curing patients the nature of whose malady they did not know, and the reason for the improvement they do not understand; but they must give the patient up for his own good. The technologist's aim is not to describe and to know, but to explain, to predict, to cure. He deals with values, with appreciations, with utility.

Thus the division of science and technology implies even personality differences as well as those of approach, of outcome and of final formulation.

(2) *The function of technology.* Science is a growing body of truth, of descriptions about reality; it is a system of propositions. Technology is a growing body of recipes, of the best ways to do things. It is a system of rules for action.

Any system of action implies normative or ethical judgments. In a certain sense even the scientist must implicitly make some moral judgments. He at least holds that he *ought* to be convinced of the truth of conclusions reached by rigorously following the scientific method. The technologist on the other hand must make, either explicitly or implicitly, types of ethical judgment at every turn. It has been the great weakness of most technologies that this has not been recognized, and their normative fundamentals systematically worked out.

Let us attempt a survey of the implicit foundations of certain representative technologies. The position of the engineer might be paraphrased in this manner: "If you want something (a bridge, a dam, a building), this is the best way to have it done." The engineer does not question very much whether the thing ought to be done. He has not asked himself what is the function of an engineer. This may be due to the historical fact that such technologists have usually had to hire themselves out to some profit-seeking individual or concern in order to practise their chosen field. The business sets the problems. Engineers who have not seen, or have not been able to carry out their functions properly, have been

instrumental in devising, constructing and distributing, say, electric light-bulbs that will burn out in a specified time; safety-razor blades that will last hardly through a shave; liquid fire, poisonous gases for use in war and in industrial disputes; and advertising campaigns that will make people glad to buy shoddy and harmful products.[3] The necessity for managers in a capitalistic system to sabotage in industry was pointed out long ago by Veblen and others.[4] The engineers have failed to see that the function of an industrial system is production and distribution for consumption of goods and not the accumulation of profits. This may be attributed in part to two reasons: the position of the engineer in industry was not such as to envisage the entire organic-like structure of an industrial society, and their training inclined them to consider themselves gentleman members of the same class of society as their employers, to consider they had the same interests and aims, the success of which they were assured could be achieved through the diligent exercise of loyal talent.

Certain consequences of the depression have changed the view of many engineers by clearly demonstrating the basic antagonism in aim and in interest between the technologists trained to serve the needs of mankind and the industrial and financial directors, trained to develop profits on investments even at the expense of the needs of mankind. We may list as illustrations: the exposure of the fairly successful attempt to buy the teaching and writing of "disinterested" professors, especially with regard to the ownership and control of public utilities; the purchase and suppression of economically valuable inventions, and the wide-spread effort to discourage further technological advances and developments; the tendency to discredit the schools and to cut drastically their appropriations, since they not only produce some technological advance but also produce a thin source of enlightened opposition; and finally, of course, the rapid increase of technological unemployment.[5]

The position of the doctor may be paraphrased: "You do want to be healthy and strong, and this is what you need to get and keep well." The physician is more closely connected in his profession with the immediate welfare of mankind than is the engineer, and is rarely in the hire of some corporation that dictates his policies and treatment. The doctor is expected to keep his patients well or to get them well as quickly as can be. While society may look with indifference or even approval upon enterprising business men who urge us to use more of some abrasive tooth paste or who try to frighten us into an addiction for cathartics or smelly mouth washes, society and the Medical Association usually frown with considerable disapproval upon the physician whose enter-

[3] Evidence may be found in the Confidential and Non-Confidential Bulletins of Consumers' Research, Inc., Washington, N. J., and in *e.g.*, S. P. Chase, "The Tragedy of Waste," Macmillan, 1926, "Men and Machines," Macmillan, 1929; S. P. Chase and F. J. Schlink, "Your Money's Worth," Macmillan, 1933; A. Kallet and F. J. Schlink, "100,000,000 Guinea-Pigs," Vanguard, 1933; T. S. Harding, "The Degradation of Science," Farrar and Rinehart, 1931.

[4] T. B. Veblen, "The Theory of the Leisure Class," Macmillan, 1908 (3rd ed., 1919); "The Vested Interests and the State of the Industrial Arts," Huebsch, 1919; "The Engineers and the Price System," Huebsch, 1921; "Absentee Ownership and Business Enterprise in Recent Times," Huebsch, 1923.

[5] The activities of the public utilities have been under scrutiny of the Federal Trade Commission for several years. Popular summaries of the findings have been written by E. H. Gruening, "The Public Pays," Vanguard, 1931; C. D. Thompson, "Confessions of the Power Trust," Dutton, 1932. The plight of the inventor is again indicated by F. J. Fraser, *Common Sense*, 3: 10, 6–9, October, 1934, and 11, 19–22, November, 1934. See also T. B. Veblen, "The Higher Learning in America," Huebsch, 1918.

prise takes the form of recommending costly and unnecessary operations to his patients. Most physicians recognize that the health of their patients is the first consideration, and a high income second.

The lawyer is a professional technician also; and the function of the law is to ease the frictions that arise in society, in a just fashion. But the lawyer even more than the engineer is a hireling representing only the interests of his employer; a mercenary who fights with equal skill and vigor on either side.

Applied psychologists, like lawyers and doctors, deal with human beings; and psychotechnologists have, like the lawyers, made their scanty living by selling their talents to business men. They hire out as super-salesmen, vocational selectors, scientific managers, as experts in soothing, mollifying and motivating the workers for the enrichment of their employers.[6] But this is hardly the proper function of psychotechnology.

(3) *The functions of psychotechnology.* The science of psychology has an advantage with regard to its subject-matter over the other sciences in that it not only may make objective determinations and measure of the behavior of its subject-matter, but can also obtain reports of the actual quality and experience of this subject-matter. Where an engineer can say how to get electric power some place (if you want it), where a doctor can say how to get out your tonsils (if you don't want them), the psychologist can say how man can get satisfaction in life. The psychologist is in a position to determine the fundamental needs and requirements of mankind, the satisfaction of which should constitute an approach to the best life. The function of psychotechnology is to determine the conditions of living necessary for a complete and satisfactory life, and to elaborate the methods for such attainment.

The elaboration of this notion of psychotechnology requires an essay possessing the magnitude of a book. The main lines of its development may briefly be indicated.

What are man's fundamental drives and motives? It appears obvious that the conditions of a complete and satisfactory life are functions of the biological and psychological characteristics of the creature doing the living. The good life for the crayfish certainly should differ in essential respects from the good life for a kangaroo; but there will be certain general conditions common to them, since they are both living creatures. The differences in detail as to the good life for various classes of animals will hence depend upon the elaboration of requirements for the expression of their special biological talents, and the satisfaction of their special cravings. From a biological standpoint a good life involves satisfactions from the fulfilment of the socially adjustive, adaptive behavior patterns. Can we agree that every animal has its characteristic genus nature; that it is satisfying for the creature to develop and express this nature; that it is unsatisfying to thwart, pervert or distort this nature?

Psychologists currently list as drives or appetites such things as thirst, hunger, nausea, lust, fatigue and the need for activity, proper temperature conditions, air, elimination, the avoidance of painful objects and the continuation of

[6] There are about 40 members and associates of the American Psychological Association now or recently in the employment of some concern, such as the J. Walter Thompson Company, Procter and Gamble, Sears and Roebuck, R. H. Macy and Company and Western Electric Company. For the type of work that has been done by psychologists see M. S. Viteles, "Industrial Psychology," Norton, 1932; A. J. Snow, "Psychology in Business Relations," McGraw-Hill, 1930; H. C. Link, "The New Psychology of Selling and Advertising," Macmillan, 1932; H. W. Hepner, "Human Relations in Changing Industry," Prentice-Hall, 1934.

pleasant and soothing objects. This list must be incomplete, for these drives are essentially visceral and automatic. These drives are common to most mammals. The list looks as though it were designed for contented cows, rather than humans. Satisfaction of these appetites is necessary, of course, to a good life for man; but they are not alone sufficient. In children and adults we can find almost universal evidence of curiosity, exhibitionism, interest in friends and in their esteem, self-esteem, self-expression and similar interests. Where do these potential satisfactions arise? Are they simply conditioned upon the satisfactions we get as infants when fed and petted by our mothers, or do they have some more fundamental biological (and hence racially permanent) basis? Biologists point out that the chief and distinguishing feature of mankind is individual variability, the capacity to learn. Our social culture is a matter of training. Psychiatrists point out that where society persistently denies to some of its members the satisfaction of basic cravings, these individuals develop psychopathic behavior. By a survey of such psychopathic behavior one can determine in part at least man's fundamental drives and cravings. G. V. Hamilton points to five major needs: a productive occupation; access to familiar sources of gregarious satisfaction; freedom to pursue and opportunities for pursuing various sexual-romantic values; harmonious domestic conditions; and conditions that make for the incidence of considerable variety of stimulation.[7] The last item is broad enough to include creative activities on the part of the more highly endowed. Although our present society fails to provide any large proportion of its members with all these types of satisfactions, no one can justly deny that society now has the technical training and equipment to provide practically every one with the first, second and last of these five classes of satisfactions. The items with regard to sexual-romantic and domestic conditions are, certainly, matters more of individual personality and taste rather than matters of engineering. Present society fails here through the improper training of the personality of its members.

What criteria and standards should be followed in developing the personalities of adults? The adult is not simply the child grown large. The variety of human cultures, primitive and civilized, attests to the plasticity of human nature within the wide boundaries set by our biological heritage. We must trace the development of the personality from egocentric childhood to socialized maturity. What are the conditions requisite for the establishment of those adult motives best suited for the good life?

Perhaps we should start in a negative way, by trying to eliminate the development of criminals, prostitutes, deceivers, scolds. But it soon appears that to stop the increase of such characters will actually involve the reconstitution of society. There must be a revolution in our attitudes and values. For it appears that the attitude of the burglar or gangster with regard to society is essentially the same as that of the munitions manufacturer, the mortgagor, the capitalist. They seek their own benefit at the expense of some one else. The robber, of course, does his business only in retail rather than in wholesale fashion and he lacks the tactical advantage of the support of the government. The proper attitude for us to have with regard to things is one of mastery and control; with regard to people, one of kindly sympathy, of allied following or leading. Most of the evils of the world come when we try to dominate other people by force for our own benefit.

[7] G. V. Hamilton, "An Introduction to Objective Psychopathology," Mosby, St. Louis, 1925.

Perhaps the most fundamental thing for us to learn is that humans are social creatures; and that it is far better to cooperate than to compete. A human being who wants to play the lone wolf is not a social creature, and the protection of society requires that he be removed from circulation. He is trying to live at the expense of his brothers: by the exploitation of people with whom he should be on friendly terms. We need to emulate the ants. Each colony of ants is one big family, the members of which cooperate to do their share of the work of the community. There is no place even for rugged wolves in a social system.

The final problem has to do with human efficiency and the economy of human energy. This is the field of applied psychology that has been widely developed, not in the interests of society at large but of those predatory interests that our haphazard civilization has permitted and even encouraged to develop. The same techniques are applicable on a wider scale. The rôle of the psychotechnologist concerns (a) the measurement of individual differences in aptitudes, abilities and interests and their proper and satisfactory utilization. With 12 to 15 million unemployed in our present unsocial society, to talk and to teach vocational guidance is viciously to jest. Yet there is elaborate equipment ready and waiting for practical use, once the mass of the members of society decide to follow the ants rather than the wolves.

Within industry the psychotechnologist (b) can aim at the elimination of fatigue and monotony. This can be accomplished in part by the introduction of proper rest and recreation periods, by the determination of the best methods of work, by fitting the machine to the worker and by determining and maintaining the optimal conditions of ventilation, illumination and the like. The analysis of the conditions and methods best suited to particular tasks that must be done will aim to achieve the maximal ease, comfort and efficiency of output. Another significant problem (c) involves the personnel relations within the industrial concern.

We are aware of our technological power to utilize nature; but we try to exercise such power over other humans. When will we recognize that we are all members of a society? The field for exploitation is the resources of nature. Let us use the methods of science for proper exploitation and for the mutual, social good.

WHAT IS A SYLLABLE?

By W. L. SCHRAMM
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THERE exist two radically different ideas of the syllable. With one the literate world has long been familiar; the other has become popular only in the last thirty years. According to one conception, the syllable is a "sound uttered with a single impulse or effort of the voice, and constituting a word or a part of a word"; in printing and spelling it is a group of letters separated, as at the end of a line, from the rest of a word or the rest of a sentence, and "capable of being uttered with a single impulse of the voice."[1] According to the other conception, there is no such thing as a syllable.

The former of these has a long tradition behind it. The earliest Greek rhetoricians spoke of the syllable. Classical verse was explained in terms of long and short syllables. In the Elizabethan age of England the Areopagitica came into existence because poets were not sure whether to form their meters with long and short syllables or loud and soft ones. At the present time, a great body of European verse is supposed to be written according to the principle of "syllable counting," whereas English and other Germanic languages base their meters on "stressed and unstressed syllables." For centuries, schoolboys have learned to spell out their words by syllables; and the ancient scribe was taught, as is the modern stenographer, to divide his words according to an established system of syllabication. This tradition has never doubted the existence of a syllable, and such a tradition is too firmly rooted to be dislodged easily.

The other conception has behind it the weight of scientific measurement. Since the late nineteenth century when the Abbé Rousselot and others first applied the photography of sound to the study of speech, psychologists and phoneticians have become increasingly impatient with the use of the word "syllable" to denote a unit of speech. They have found that connected speech is a flowing current of vocal melody, broken only by such things as stopped consonants and phrasal pauses. In most cases, they are quite unable to find within a word or a phrase definite points at which the sound might be divided into units called syllables.[2] They feel, therefore, that the syllable is a visual, rather than an oral and auditory unit. They ask, in all justice, that a language should be analyzed according to the way it sounds, not how it looks; and in opposition to the syllabic tradition they offer their photographs and their charts, and challenge the doubters to inspect the evidence, and find syllables if they can!

In the first place, connected speech is a continuous flow. The old tradition visualizes connected speech as a chain made up of links, each link a syllable. Supposedly, one could remove a link from any point in the chain and study it. But the phonophotographs have re-

[1] These statements are based on text-book and dictionary definitions of the syllable. The quotations are from Webster's New International.

[2] It has become the fashion to speak of "speech atoms"—small portions of the speech inscription "during which the character of the movement remains practically unchanged"—and of "speech molecules"—portions of speech set off by breaks in the sound. See F. Janvrin, "The Atomic Structure of Speech," in *Archives Néerlandaises de Phonétique Expérimentale,* Tome VI (1931), 101–04.

vealed no such structure. The only breaks within the speech current are those created by the ending of a phrase, by an interphrasal pause for the sake of elocutionary emphasis or by stopped consonants. The scientist conceives the speech current, therefore, not as a chain made up of detachable links, but rather as a metallic bar, which may vary in size and composition along its length, but which is still a unit.

In the second place, there is no definite point, except those mentioned above, where one kind of sound may be said to replace another. The syllabic tradition has conceived of speech as something like the shifting of gears in an automobile. The driver pulls the lever into the left rear position and the car moves in low gear; he shifts the lever to right front, and the car is in second gear. And so a speaker sets his vocal organs in one position, and says a certain vowel; he shifts the position and says another; and thus throughout his sentence. This belief is an outgrowth of the theory that vowels and other speech sounds are the products of *positions* of the vocal organs. It has now been shown by means of x-ray photographs and the registry of sound that speech sounds are the results of *movements*, rather than positions.[3] The vocal organs glide smoothly through a phrase, and there is no sharp and definite point of delimitation between one vowel and another, because the quality of the sound changes gradually with the gradual movements of the tongue, the pharynx, etc. Let us take an example. A speaker is pronouncing the word "alone." There will be observable on the phonophotographic film a period when he is known to be pronouncing the first vowel. There will be a following period when the "l" sound is beginning to creep into the vowel. Then there will be an almost pure "l" sound, then a combination into which the second vowel is entering, the second vowel, nasal elements in the registration which indicate that the "n" has appeared, and finally a slight explosion to indicate the release of the nasal. No observer can select the point where the "a" ends and the "l" begins. Phonologically the word is indivisible into syllables. To return to our former illustration, we may say that the human voice has been shown to be a very flexible instrument which does not need to change gears to change sounds. In the Germanic languages, at least, the glides between sounds are so gradual that it is usually impossible to distinguish a point of demarcation.

Although the measurement of sound has been developed to a point of great accuracy—pitch can be measured to 1/1000 of a tone, intensity to 1/10 decibel, time to 1/1000 second, timbre to one per cent. of change in harmonic composition—there is no system of measurement in existence which can delineate either boundary of a syllable unless that syllable is initial or final in a phrase or is bordered by a voiceless consonant. Even in the latter case there is grave doubt as to where the consonant belongs. For example, the first syllable of the word "opera" is, by tradition, "op." The photographic measurement of this word shows a certain amount of time expended in pronouncing the vowel "o"; then a pause, while the lips are closed preparing the "p"; and finally the explosion of the "p" and the next vowel. The problem is, where does the

[3] See E. W. Scripture, "Zur Psychophysik und Physiologie der Vokale," *Zeitschrift für Sinnesphysiologie*, 58: 195–208, 1927; "The Nature of the Vowels," 1931; and articles in *Zeitschrift für Experimentalphonetik*—especially "Die Natur der Vokale" (1928). Professor Scripture has expressed an opinion almost at the opposite extreme from the traditional idea of the production of vowels. "Exactly the same vowel can be produced by very different movements," he wrote in 1931. "There are no 'cardinal vowels' with typical tongue positions; different persons make the same vowel with utterly different movements" —"What is Experimental Phonetics?" *Modern Languages*, February, 1931.

second syllable begin? Phonologically, there is no more reason to count the pause with the first vowel than with the second. Even if it is given to the first vowel, does the second syllable begin exactly at the end of the pause, or must some of the duration of the sound after the pause be accredited to the "p"? Such cases as this cause a scientist to lose patience with the syllable. And it is true that from the standpoint of one who considers a unit of speech to be a definitely delineated part of speech, the syllable simply does not exist. More nearly exact units are the speech atom and the speech molecule.

In the third place, there is grave doubt concerning the traditional theory of the production of a syllable. "A syllable is a sound capable of being uttered with a single effort or impulse of the voice"—that is a part of nearly every definition. Yet the simplest phonophotograph will show that a great many of the units commonly called syllables are *not* capable of being uttered with a single effort or impulse of the voice. This is especially true of monosyllables. Any monosyllabic word which ends in a plosive or in a plosive followed by a spirant requires more than one impulse of the voice. Such words as *plot, take, bad, bog,* require two definite sounds. The lips close before the plosive, there is an interval of silence, and then the lips open and the explosion takes place. Are these to be considered disyllabic? And are such words as *whisks, mosques, asks,* to be considered trisyllables? This is surely a serious objection to our traditional conception of the syllable.

But we can not argue the syllable out of existence quite so easily. For thousands of years we have been hearing elements of speech which we have called syllables, and when we have written we have not hesitated to indicate those syllables by means of letters. It may be well to inquire what we have been hearing. When we hear a line of verse we can usually tell how many syllables it contains. What do we mean by this? We mean, usually, that the line contains a certain number of stresses. The syllable usually has a definite stress of its own, and at the high point of that stress it has a tone quality different from those of the stresses around it.

A line of verse or a phrase of connected prose may be thought of as a mountain chain. The peaks are of different heights; they are of different shapes and colors; and, although they are strung together like bumps on a central ridge so that one is never sure where in the intermediate valley one ends and the other begins, still one never doubts their identity. If he climbs one peak he knows he is not on the mountain to the east, although he might not know exactly how far eastward he would have to walk before his mountain ended and the next one began. When he stands in the distance he can see that there are a certain number of peaks. So it is when one hears a line of verse or a phrase of connected prose. He is conscious of peaks which are of different heights, shapes and colors, although he is unable to tell precisely where each begins and ends. Fig. A shows the mountain chain of speech. Here we have an intensity curve of a line from Antony's speech in "Julius Caesar" (III, ii). It has been traced from a phonophotograph in such

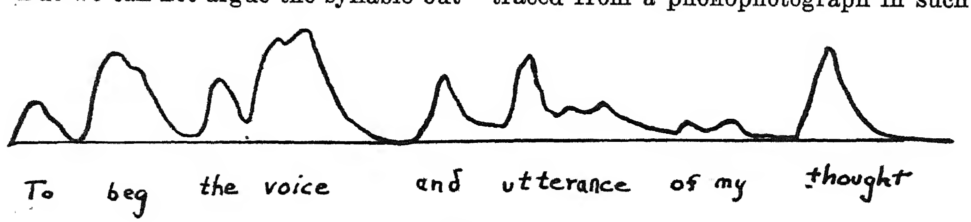

FIG. A

a way that the height of the peak is proportional to the loudness of the sound. You will observe that there are as many peaks as there are syllables. Because a definite delineation is not always possible is no reason that these syllables do not exist, any more than mountain peaks do not exist. We may admit that a syllable is not a quantitative unit, without admitting that it is not a qualitative one. It may not be a useful unit of duration, but it may still be a useful unit of quality and intensity.

It does not seem necessary, therefore, to abolish entirely a term which has been useful for thousands of years, but if we are going to continue to use that term it is only reasonable to reappraise it, to define it clearly in the light of our new knowledge, and to use it more carefully. Our new knowledge of the syllable may be summarized under three heads:

(a) We may as well admit that our visual conception of the syllable, our dictionary and spelling-book division of a word has no justification other than custom in use, convenience in teaching, and descent from languages which added many endings to indicate case, tense, number and gender. We may as well admit that our stenographers are forced to learn a purely arbitrary system of division which is neither more handsome nor more correct than several other systems; that our school children are taught to syllabicate by a system which, if carried into vocal practise, would result in an unnatural pronunciation; and that when we divide a line of verse into syllables we are treating an auditory matter by a visual rule, and moving farther and farther from the intent of the poet and the beauty of the verse. A syllable is not a group of letters.

(b) We may as well admit also that, except in certain special cases, the syllable is of no use as a unit of duration. That is not to say that a syllable does not give the *impression* of duration. It does; but what we have measured as the duration of syllables has been the duration of certain units of sound plucked out of connected speech by an arbitrary rule. It has been the custom, for example, to determine the length of a syllable by measuring the time between the points of lowest intensity on either side of its peak.[4] This method is of some use in studying rhythm, but it is not a measurement of *syllable* length. It is a measure of a purely arbitrary unit of speech.

(c) Until more delicate investigation proves otherwise, we may consider the syllable to be the seat of a stress, differing from its neighboring stresses either by intermediate silences, by different tone color or by an intermediate diminution in stress; and if we must place the syllable definitely in time we may locate its center as the highest point of the energy applied to it—the top of the peak which its intensity builds up and upon which its tone color is distributed.

A syllable, then, is not a definite part of a word; it is, rather, a dynamic phase of a word, and "syllability" (*Silbigkeit*) has been suggested as a more accurate explanation of that character. "Es gibt Silbigkeit aber keine Silben," declares Professor Scripture.[5] But it seems hardly necessary to change the word, as long as we recognize clearly that our visual system of division into syllables is mostly a pleasant fiction, that the syllable is of no practical use as a unit of length, and that when we say a word has a certain number of syllables we mean merely that it has a certain number of important stresses and a certain number of distinctive tone qualities coincidental with those stresses.

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[4] This method was used in my article, "Time and Intensity in English Tetrameter Verse" (*Philological Quarterly,* XIII: 1, 65–71, 1934). Since then I have come to think that a more accurate study of rhythm may be made by measuring from peak to peak.

[5] E. W. Scripture, *Grundzüge der Englischen Verswissenschaft,* 27. See also his article, "Die Silbigkeit und die Silbe," *Arch. f. d. Stud. d. Sprachen,* CLII: 74, 1927.

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WHAT COSMIC RAYS TELL US

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"COSMIC" comes from the Greek word "cosmos" and means an orderly and harmonious universe. "Cosmic ray" then refers to a ray coming, not from a chaotic, but from an orderly universe. It is a name applied first by Dr. Robert A. Millikan, of the California Institute of Technology, when he showed beyond all reasonable doubt that there was a very penetrating ray, or radiation, coming in from the space around us. Such a name is exceedingly fitting, for with all our modern methods of prying secrets out of nature we have come back more and more to the old Greek idea of essential order and harmony, of a purposeful universe, each part of which plays an essential rôle in the scheme of the whole.

That man was so long in ignorance of this radiation is not surprising, for it is only in very recent years that he has developed means of detecting its feeble influence. But so keen has been the interest and so rapid have been the developments that to-day we have three separate and distinct means of detecting and measuring cosmic rays. Nor has this interest been limited to men of science. The layman has shown an eagerness for knowledge and a desire to cooperate which has greatly aided the acquisition of new facts so that all might know more of what cosmic rays have to tell.

The search for new knowledge has caused men to risk their lives on ventures to the far-flung reaches of the world. This has always been so and will always be so. It provides the romance of adventure and the means of satisfying man's innate curiosity to know more of the world in which he lives. It has been the means of freeing him from the bonds of ignorance and superstition; it has given him confidence in himself where now he is ruler of the world around him instead of being ruled by that world.

In the truest sense of the word man's quest to know more of what cosmic rays have to tell is a romantic story. The earth is his laboratory, and all that there is in it he uses to further this end. His quest has led him into the northern and southern arctic zones and to equatorial regions. It has caused him to climb the highest accessible mountain tops and to sink instruments into deep lakes. He has flown in huge airplanes to great heights carrying shields of lead weighing half a ton to make soundings higher than could be reached on mountain peaks. The same quest has been the chief scientific object of all flights into the stratosphere, and without doubt many another trip into the high reaches of our atmosphere will be made for the same reason.

The search goes on, but let us pause to take an inventory of some of the major things that cosmic rays have to tell us. Our procedure will be, first to ascertain the facts and second to formulate a theory which will be self-consistent and which will point the way to new experiments and eventually to new facts.

One of the very first and one of the most important discoveries made was that this radiation is the same day or night. This at once tells us that it can not come from the sun. We would next suspect the stars, but here also when the greatest number of stars is in view, namely, when the Milky Way is overhead, we find no change whatever. These facts alone seem to point to an origin in space itself. Of this we are still in doubt, but let us consider some further facts.

Comparison between northern or southern latitudes and equatorial zones reveals a distinctly less amount of cosmic radiation in the equatorial region. Many theories have been advanced to account for this, but the most likely is the influence of the earth's magnetic field. To understand how this might be possible, let us recall that the earth is an enormous magnet with a north and south pole and that electric charges moving in a magnetic field are deflected to one side. At least part of what we call cosmic rays, then, enter our atmosphere as electrically charged particles. Those arriving at or near the equator are more strongly influenced by this huge magnet than those coming in near its poles. Some, or perhaps most, of them are thus eliminated near the equator before they reach the earth. We may call this decrease as the equator is approached the "latitude effect."

Now, surveys of the past have disclosed a marked difference in the magnetism of the earth between the eastern and western hemispheres, it being much weaker in the western. Cosmic rays tell us much the same story, but they tell us more, for their story is their history after having been under the influence of the earth during the last ten to twenty thousand miles of their journey through space. They thus furnish a means for the first time of studying the properties of the earth's magnetism at great distances. This difference in cosmic radiation on the two sides of the earth is called the "longitude effect."

It appears, however, that these particles which cause the latitude and longitude effects do not tell the whole story, for it seems impossible at the present time to explain all the facts on this basis. That there are some charged particles coming into the top of our atmosphere we feel certain, but there must also be a radiation of a different sort which forms other charged particles in our atmosphere and accounts for the major part of the radiation. This second kind of ray appears to be light-like in nature and to have the ability to penetrate several hundred feet into the earth. It is near the equator that we can best study this latter type of radiation, for there the number of external particles mixed in appears to be comparatively small. Much of the work in the future will undoubtedly be done in the equatorial regions, for it has become increasingly evident that here the properties which will tell us most of the nature of cosmic rays are best defined.

These charged particles we have been speaking of are called electrons—the smallest bits of electricity and mass known. The energy of some of them is enormous. There is a hundred times as much energy in some as they would receive from the longest lightning flash, and because of this energy can penetrate several feet of lead with ease.

At sea level the number of particles striking every one of us and going completely through our bodies is from ten to fifteen every second. That we are unaware of them is not strange, for in the first place they are exceedingly small and in the second place they are few in number. Although each and every particle affects us to some extent, the result of even the hundreds of thousands of these particles penetrating our bodies every day is too small to be no-

ticed. What may have been the accumulative effect on the biology of life on the earth throughout all time one can not even guess.

If we were to go to the top of Pike's Peak or fly in an airplane at 14,000 feet we would be exposed to four times as much radiation as we get at sea level. Going to great altitudes the cosmic rays increase very rapidly until at the height reached by stratosphere balloons the occupants of the gondola are struck by several hundred times as many particles as at sea level.

Although the facts are not all in it is nevertheless possible to make intelligent guesses as to the origin of these rays. Dr. Millikan made the stimulating suggestion a number of years ago that they resulted from the act of building the heavier elements, such as helium, oxygen and iron from the lightest of the elements, hydrogen. This process was assumed to be going on in the intense coldness of space. Sir James Jeans has championed the idea that they result from the destruction of matter altogether. A third possibility, suggested by Dr. Fritz Zwicky and Dr. W. Baade, is that stellar catastrophies known to astronomers as super novae may be the origin of these rays. At times an inconspicuous star will suddenly increase in brilliance many thousand fold, reaching temperatures reckoned in millions of degrees. Its maximum brilliance lasts for a few days and then it gradually subsides, usually diminishing to such an extent that after a few months it can no longer be seen. The nova which appeared in the constellation Hercules in December of last year, even though it became one of the brightest stars in the heavens, owed its brilliance to its nearness and was not of the super-nova class. So far there is no conclusive evidence that this nova is giving off cosmic rays. Still a fourth possibility is one suggested by Professor Le Maitre. He wishes to view the present existence of cosmic rays as evidence of bygone days when the universe was young and unstable, and now that it has reached a more mature age, has stopped its frivolous ways, but the remnants of its past are still traveling through space, striking whatever might cross their paths.

Whatever may be the ultimate story cosmic rays have to tell, certain it is that it will be of interest to all. It may be a story of the formation of new matter or the death cry of old. Time only will bring an answer. In the meantime the search for new facts goes incessantly on, but still more incessantly come the cosmic rays themselves, undiminished and undisturbed, fulfilling some as yet unknown purpose in the general scheme of the universe.

ENDOCRINE FACTORS IN PERSONALITY

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Every one knows in general what personality is, but no one has satisfactorily defined it. It includes everything that gives individuality to the individual. The problem then is, what do the glands contribute to the make-up of the particular self of each of us?

Every one has many glands. These are actually living chemical laboratories. Well-known examples are the salivary glands that keep the mouth moist, the tear glands which upon occasion cause salt water to trickle down our cheeks or the glands in the skin that help keep us

cool in summer. These all take from the blood that courses through them different substances which are combined to form secretions. These secretions then pour through ducts to their various spheres of action. The glands which we are to consider, however, are different from those mentioned. Their secretions instead of being discharged through ducts are returned directly to the blood stream. Thus they are distributed throughout the body to produce a large number of important effects. These regulatory substances are known as the internal secretions or the hormones.

The hormones are among the most powerful of all known drug substances. For example, each of us has in circulation in his body at any one time about one fifth of a grain of a necessary hormone from the thyroid gland. In the course of a year we use about three and one half grains of this substance all told. This is a little more than the equivalent of half an aspirin tablet. Yet we are all dependent upon this small pinch of material substance, thyroxin, to keep us from becoming complete imbeciles—the statement is literally true. Without thyroid secretion the human being becomes merely a sort of walking vegetable. There are several other hormones equally potent, or even more potent, upon which we are fatally dependent either for existence itself or for the ability to make existence worthwhile. All these affect personality.

From certain writings of recent years one might get the impression that personality depends upon little else than hormones. Such is emphatically not the case. Many factors go into the determination of individuality. In the make-up of the personality the two most important features are the mentality and the emotions. The quality of the mind determines whether the individual is intelligent or stupid. Intelligence depends primarily upon the kind of brains one gets from his ancestors, but development of the brain as well as the way it works is to a considerable degree determined by the hormones. Even more important than the intelligence, however, are the emotions. We like one person because he has a jolly, sunny disposition and dislike another because he is glum or conceited. The emotions are closely related to the instincts. Indeed the emotions might be said actually to represent the way the instincts feel to the person who has them. The instincts are substantially determined by hormones both in their quality and in their intensity.

We may now consider some of the glands individually. Suspended from the brain in the center of the head is the pituitary gland. When this gland fails to develop properly the individual remains of small stature throughout life. His littleness sets him apart from others of his age and this very fact of being different reacts upon his personality every day. He is always under an inner necessity to try to compensate for his appearance of physical insignificance.

Should the pituitary become overactive during childhood the result is over-growth. There is now living in a Middle Western state a boy of 17 who, because of the possession of an overambitious pituitary, is over 8 feet tall. He can readily tuck his full-sized father under one arm and carry him about the house. Should over-activity of the pituitary begin after the child has grown up a different state of affairs arises. No longer is symmetrical development possible, but the excessive growth takes place only in selected parts of the body. He becomes a gorilla-like monstrosity, a so-called "acromegalic." His deformities have of course a constant tendency to warp his personality. But he has more to contend with. During the early stages of the over-growth he is vigorous and virile. If the distortion is not too great he may even turn it to advantage

as once did a celebrated baseball player who had this disorder.

With his enormous hand and powerful muscles he was able to pitch a remarkably deceptive curved ball. He was alert and resourceful. But after awhile the large pituitary gland began to fail, as it commonly does both in giants and in acromegalics. The case of the baseball player is rather typical of what occurs in such cases. After a few years he began to slip. He lost his muscular control, became timid and hesitating and after a very few seasons in second or third rate teams he left baseball and spent the rest of his futile life as a pool-hall loafer. He was first a brilliant success by virtue of his pituitary secretion and ultimately a pitiful wreck when he was deprived of this stimulating hormone.

Another hormone from the pituitary determines sexual development. Should this hormone not be secreted in proper amount the individual remains throughout life sexually and emotionally a child. The fanatical reformer is likely to be a person of this type. Having no possibilities in himself of satisfying self-development, he attempts to compensate by making over the world, and thus gaining a sense of power.

From the pituitary another secretion that regulates milk formation has recently been discovered. During the later stages of pregnancy and after the birth of the infant this hormone aids in keeping up the maternal food supply for the child. It is definitely true in experimental animals and probably will prove to be true in human beings that this latter hormone—prolactin it has been called—is an important factor in setting up and maintaining not only milk secretion but the maternal instincts as well. Under its influence unmated female rats have been made to adopt and mother large families of babies and roosters have been made to cluck. I would not care to say that human mother love is merely a matter of hormone chemistry, but I suspect that the future will show prolactin to have a significant part in this emotion.

In the lower part of the neck lies the thyroid gland. When its secretion is completely lacking the individual lives at only about half the normal vital speed. He is listless, mentally stupid and sluggish of memory. Aside from a tendency to subdued truculence his emotional life is almost colorless. Fortunately, thyroid deficiency of this marked grade is rare. Unfortunately, however, lesser degrees of thyroid deficiency are quite common and are frequently overlooked even by excellent physicians.

The victims are likely to be overweight, though this is by no means always the case. They fatigue easily and on slight provocation become cross and irritable. They are able to pull themselves together for brief periods but soon relapse again into their feeling of inadequacy. Statistics on this subject are not available, but it is altogether probable that a considerable proportion of the unfortunates who go through life labelled "neurasthenic" or "psychoneurotic" are victims of this mishap.

Let me emphasize that there are many other causes than thyroid deficiency for this state of affairs, but in those cases in which it is the cause the condition is readily corrected. Sometimes even as little as one tenth of a grain of thyroid substance a day is sufficient to add materially to individual comfort. Commonly less than one grain a day is needed.

Unfortunate as are the results of thyroid deficiency even worse is the opposite condition. Over-activity of this gland gives rise to a condition of alert tenseness by which the person may be driven to death. He may live at twice the normal speed. Even with a voracious appetite he is unable to keep the vital furnace adequately stoked and often literally burns himself out.

The thymus gland in the upper part

of the chest has long been under study, but until recently little convincing evidence of its importance had become available. It was believed to have something to do with development and that when it was defective the individual remained weak and futile in his personality. Within the year, however, it has been reported that thymus extract can produce in the offspring of treated animals a remarkable precocity of development. When only a few days of age the baby rats were as advanced as they should have been in a month. It is as though human children were ready for high school at the age of three years. The extract has not yet been tried in any extensive way on human beings, but the experimental evidence suggests that it may some day prove to be an important resource in the treatment of retarded children.

The adrenal glands which lie just above the kidneys also contribute to personality. From these glands is derived the well-known hormone "adrenalin." It is probable that this secretion plays no significant part during times of ordinary quiet existence, but that under emotional stress it is discharged from the gland and has important stimulating effects, that permit us better to muster our bodily resources to meet emergencies. Without the aid of adrenalin we should no doubt be less competent in emergencies and our personalities so much the less effective. In the primitive scheme of existence emergencies called for activity—and adrenalin secretion was probably always helpful. Nowadays, however, emergencies often call, not for immediate activity, but for self-control and calm thinking. Nevertheless, in such conditions the adrenal glands still pour out their stimulating secretions and thus add to the difficulty of remaining calm and collected. It is this behavior of the adrenals which probably gives much of its point to the old saying that "worry is worse than work."

From the adrenal gland is obtained also the hormone "cortin." This substance has only recently become available and its properties are not well known. It seems to influence all the living cells of the body. When cortin secretion fails the individual develops Addison's disease, a condition in which the personality suffers. The patient becomes physically weak, restless, irritable and uncooperative. When cortin is supplied artificially there results a restored sense of well-being, of energy and of enthusiasm. So much for extreme conditions. What part cortin may play in ordinary everyday life, and especially its influence upon the personality, have not yet been adequately studied. There are on record a few cases in which the adrenal glands have become enlarged and in which the individual, whether male or female, acquired a marked accentuation of masculine attributes. These cases suggest that the adrenals may contribute a quality of virility to the personality, but the quality has not yet been obtained in adrenal extracts.

Finally a few observations may be made about the sex glands. From time immemorial these organs have been removed from farm animals to bring about docility of temperament and to facilitate fattening for market. When the glands are removed before maturity either in animals or in human beings the result is essentially the same in all cases. The individuals fail in sexual development. They are more or less lacking in vigor and initiative, though the operation is not actually the ruinous calamity that it is popularly supposed to be. In the experimental animal the mating instincts fail to develop and in the human subject normal romantic interest in the opposite sex is not acquired as the individual reaches adulthood. When the operation is performed later in life the

effects are somewhat variable. A certain degree of instability of temperament is likely to develop and, in women especially, unusual irritability may be apparent. Individuals of both sexes tend to become over-weight.

The foregoing constitute but a few of the outstanding facts which bear on the subject. The relation of the hormones to personality is one of the most interesting and perhaps is the most important topic in the whole field of the internal secretions. Unfortunately, however, the psychological has been the most neglected aspect of the subject. The result is that this important chapter remains yet largely to be written.

Nevertheless, we can safely say that the personality is importantly determined by the influence of hormone factors. There are several hormones, the complete lack of any one of which would essentially ruin the personality. Without his hormones no individual can be normal either physically, mentally or psychologically. Recognition of this fact, however, should not blind us to the further fact that personality is a very complex matter and is dependent upon many other than glandular factors.

PREVENTION OF FOOD POISONING

By Dr. K. F. MEYER

DIRECTOR, HOOPER FOUNDATION FOR MEDICAL RESEARCH, UNIVERSITY OF CALIFORNIA

THIS program is addressed to all people who believe they have experienced a touch of so-called "ptomaine poisoning." Theoretically, therefore, I should be speaking to practically every one in the United States, for in spite of the fact that there is no such thing as ptomaine poisoning it is one of the most popular of indispositions. It is a blanket term applied to any ailment that appears to have its origin in the stomach and to have been caused by the ingestion of some questionable food substance. As a matter of fact, there are a dozen different causes which may underlie those excruciating symptoms which lead us to sigh, "It must have been something I ate." Some of them are not due to the nature or condition of the food at all but to misuse of the food or to our own peculiarities, temporary or permanent. Others are due to different kinds of food poisoning.

Overeating, overdrinking, exposure to cold after eating, fatigue or bad water may induce gastric disturbances resembling those from food poisoning. Furthermore, some people are abnormally sensitive to certain foods and may react violently to them, even though the foods themselves are absolutely harmless. For such attacks it would probably be better not to use the term "poisoning" at all. Technically, food poisoning is restricted to illnesses caused by naturally poisonous plant or animal matter, by accidental inclusion of some metallic poison in foods and by chance contamination with toxin-forming bacteria or other microscopic forms of life.

As an example of foods that are naturally poisonous it is scarcely necessary to remind you of the toadstool and similar varieties of toxic fungi. The danger of poisoning from this source is easily avoided by making certain that fungi are edible before using them. This can not be done by any magic trick, such as dropping a silver coin in the cooking receptacle. The best plan is for the private individual to learn how to identify one or two harmless species of mushrooms and to confine himself to those. Professional gatherers may obtain valuable information on the subject by consulting some authoritative classification

such as that offered by Krieger in the *National Geographic Magazine* of May, 1920.

Another curious example of naturally poisonous foods is provided by the common sea mussel in certain parts of the world. In recent years this cause of food poisoning has assumed great importance on the Pacific Coast, from Monterey in California far into Alaska. During the summer months these shellfish develop a poison which is, as far as we know, the most active toxin on record. As a means of preventing food poisoning from this source the State Department of Public Health has lately established an annual quarantine on mussels from early June until late September. Despite this safeguard individuals still insist on gathering mussels and eating them at home, occasionally causing death and often with less serious results. To be safe one should avoid these shellfish during the summer months, or if that is impossible, care should be taken to neutralize any poison that may be present. This may be done quite easily, investigation shows, by cooking the shellfish for twenty or thirty minutes in boiling water containing a quarter of an ounce of ordinary cooking soda for each quart. Numerous tests indicate that this procedure destroys about 80 or 90 per cent. of the poison and thus renders the mussels safe for consumption.

However, cases of food poisoning arising from these inherently toxic substances are in the minority. The primary causes of food poisoning are a number of varieties of microscopic plants and animals that get into the food while it is being prepared for use. Of course, there are also many actual disease organisms that contaminate food and enter the body through the mouth. Among the diseases that may be acquired in this way are trichinosis, dysentery, typhoid fever, septic sore throat, etc. These are not strictly food poisonings but are food-borne infections. In passing, however, it should be mentioned that trichinosis is entirely too prevalent in the United States at the present time. People should remember that this dangerous disease almost invariably comes from improperly preserved sausages, especially salami, or from insufficiently cooked pork products. Commercial sausage manufacturers may eliminate trichinosis by holding all pork for twenty days or longer at a temperature of 5° Fahrenheit. If this can not be done the ground meat should be mixed thoroughly with salt and after stuffing in the sausage casing should be held in a dry oven for not less than twenty days at a temperature not higher than 45° Fahrenheit. In making sausages at home these procedures are not practical, and it is therefore advisable to avoid the preparation of sausages which are eaten without cooking. *In the use of fresh pork safety may be assured by boiling or roasting it until the flesh is of a white, opaque color.* Care should be taken also not to give raw pork to domestic animals or to allow rats to reach it, as the disease may be spread in this way if the meat contains trichina (worms).

Typical food poisoning of a bacterial nature, however, is more predominantly gastrointestinal in its symptoms than the diseases I have just mentioned and usually develops within a few hours after eating contaminated food. While present-day knowledge of all the forms of microscopic life involved is far from complete, there are a few facts which can be presented. Hundreds and even thousands of cases of such poisoning undoubtedly occur without receiving a thorough scientific examination. Usually it is only when a large number of people are affected simultaneously, following a dinner, luncheon or picnic, that an investigation is made. Many such investigations by modern scientific pro-

cedure have revealed that a common form of organism resembles the typhoid fever bacillus in many ways and is therefore called the paratyphoid bacillus. It is not always possible to discover how this bacillus gets in the food, but in some cases it has been found that contaminated meat products came from animals infected with paratyphoid bacilli. In other cases the meat was contaminated after being slaughtered. In some countries where emergency slaughtering of beef animals is practiced, paratyphoid or Salmonella contamination from sick calves and cows is more prevalent than in the United States. Here it seems probable that contamination is more likely to take place during the handling of a foodstuff. This contamination may occur through a human carrier of paratyphoid infection or from infected animals such as house rats. It has occasionally been found that food poisoning has occurred as an aftermath of a rat extermination campaign where so-called "rat viruses" or living cultures of paratyphoid bacteria had been carelessly used. These methods of combatting rats are dangerous as well as ineffective and there is no justification for their employment. If efforts are made to keep the rat population at a low level, cleanliness and care, systematically practiced, will protect food supplies from contamination by rodent contact or droppings.

It should be remembered that food made dangerous by paratyphoid contamination is not readily detectable. It is not necessarily altered in appearance, smell or taste. The way to avoid it is by eliminating all opportunity for contamination. Thorough cooking and storage under refrigeration diminish the hazards of food poisoning. The eating of raw meat products involves a constant risk of poisoning. If animals to be slaughtered are given a careful inspection by trained men, and if meat from them is thoroughly cooked, the hazard of food poisoning is not very great.

Meat products are not the only media acceptable to microscopic organisms capable of causing food poisoning. A number of cases have been studied which apparently were caused by a toxin elaborated by the Staphylococcus, an organism vaguely resembling a Lilliputian bunch of grapes. The truth of this was checked by a volunteer group of scientific workers who swallowed small amounts of fluid in which staphylococci had been growing. The fluid was found to be a highly irritating metabolic poison. In about two thirds of the cases reported, this type of food poisoning has resulted from eating improperly refrigerated pastry, especially pastries containing cream or custard filling. Public health workers have found that this form of poisoning can be prevented by thoroughly cooking pastry filler and then promptly cooling it under refrigeration. Also, all utensils, such as filling bags and guns, must be sterilized daily and kept clean at all times. The production and distribution of cream pies or cakes during the warm summer months should be restricted to bakeries properly equipped with refrigerated storage or display cases.

Last but not least of the causes of food poisoning is the *Bacillus botulinus*. It is probably the most dangerous of all, involving a poison second in virulence only to the mussel poison previously mentioned. Fortunately, botulism is also more readily prevented than other types of food poisoning. It grows only in sealed containers or in food masses from which oxygen is excluded and this growth may be prevented by the application of sufficient heat. During the past 150 years the deaths of about 500 people have been traced directly to botulism. At one time it offered a serious threat to the canning industry of the

United States. Through extensive experimentation over the course of many years methods have been evolved to eliminate botulism and as a result not a single case of botulism has been traced to a commercially canned food for the past ten years. There have been some fifty cases of botulism, but in each case the source was an improperly prepared home-canned food.

Because of the fact that the state of California is one of the important canning centers of the world, the responsibility for the campaign against botulism has largely devolved upon the University of California. Members of its staff have found that the Bacillus botulinus is to be found everywhere in the soil. Thorough washing of fruit and vegetable products minimizes the chances of contamination but does not eliminate them. Certainty of freedom from botulism can be obtained only by cooking susceptible preserved products at very high temperatures. These temperatures must be above the boiling point, for the spores of botulinus have been known to withstand six hours of boiling. In commercial canneries this problem has been met by pressure cookers employing live steam, and by scientific tests a correct processing time has been determined for each important food. There are certain rules that every housewife should observe in order to avoid botulism. All home-canned, non-acid foods should be thoroughly boiled just before eating. This will destroy any poison present. Canned products should always be opened by an adult familiar with their normal appearance and odor. If there is the least trace of off-standard condition the product should be ruthlessly destroyed and never fed to animals or fowls. If there is no pressure cooker available in the home preserving of non-acid foods, it is safer to substitute drying, salting or pickling for canning.

A FREAK OR EVOLUTION?

By Dr. CHARLES T. BERRY

DEPARTMENT OF GEOLOGY, THE JOHNS HOPKINS UNIVERSITY

By what criterion do we distinguish between a freak and evolution? This is a puzzling question and one which is raised in connection with the conditions of the two animals I will tell you about in this paper. Nature tries a certain line of development, and if it does not prove to be efficient in the surroundings where it is placed, this line is either changed or discontinued; and in its place nature installs another variety. Do we term this unsuccessful line a freak or evolution? If we should find one specimen we should probably call it a freak, but if we have the entire line made up of what individually we might call freaks we would term it evidence of evolution. Likewise if we separated one of the links out of this long chain of evolution and placed it near one of the end-members of the chain we would be tempted to call this individual link a freak, whereas in reality it is just a step, in the line of evolution, out of order. This is the question brought out by the abnormalities in the two following cases which I want to describe. Are these turtles freaks or steps in evolution?

During my wanderings around Maryland in connection with some geological work I was doing three summers ago, I stopped to rest on the bank of a small stream in Calvert County. Being interested in all things pertaining to natural science I started to look around while I was eating my meager lunch. About fifteen feet from the bank of the stream I spied the empty shell of a turtle with a number of the outer epidermal scutes detached from the bone. I examined the remains more carefully only to discover that there seemed to be an extra plate on the turtle's back. I at once carefully gathered up all the remains I could find and packed them away, to take back with all my fossils to the laboratory. Once back in the laboratory, and my material unpacked, I looked at this turtle better and sure enough, there was an extra plate on its back. I put this specimen aside, since my geological work was occupying all my time, and did not think of it until I came upon another turtle shell some ten months later in Howard County, Maryland.

This shell also had an extra plate on it, but it was not the same one. However, I was not so fortunate with this specimen, for all the epidermal shields were fastened very tightly to the bone. These two finds aroused my curiosity very much, and from that time on I have been examining every turtle I have seen. Over a period of several years this amounts to quite a number. On none of the other turtles have I found any evidence of an extra plate. These two finds of mine are apparently just a coincidence.

This is the question. Is the presence of these extra plates a step in evolution or does it represent just freaks? Whichever is the case, they are of interest to the naturalist.

Both of these specimens belong to the same species—*Cistudo carolina* Linné. or the common box tortoise which is often seen in and around gardens and in the thinly wooded regions where there is sufficient moisture. This turtle lives to a very old age—the exact length is unknown—for they have been kept in captivity only about fifteen years. They wander about and do not dig holes in

the ground except in the winter time, and then they are liable to bury themselves to a depth of two feet or more. *Cistudo carolina* has a range from New England southward to Georgia and westward to the Mississippi River.

This common box turtle has been called by several different names, among which are *Testudo carolina* and *Didicla carolina*. These are still used by some authors; however the term *Cistudo carolina* is in good usage to-day and I will follow the current practice.

The first specimen (Fig. 1) which came from Calvert County had apparently been lying exposed all winter, for the scute plates had become detached from the bone, permitting me to observe the epidermal shields separated from the bone. This specimen has an extra scute plate situated on the left of its third vertebral plate, and partly intercalated between the second and third costal plates. The illustration is taken of the naked carapace with all the scutes removed so as to show how deeply the actual bone is grooved at the contact of the individual scutes. This extra triangular plate, which is very well marked off, is a little more than twice as long as it is wide. This scute plate shows all the usual growth markings and appears to be a unit in itself similar to all the normal scute plates.

There is, however, a slight irregularity in the color pattern on the right side of the third vertebral scute; but not enough to justify drawing any conclusion as to whether a similar plate might have been formed there or not. I examined the surface of the bone very carefully and there is no evidence that any extra plate might originate on the right side. I traced out the suture between the bony plates and could observe no irregularities due to the presence of the extra scute plate.

This Calvert County specimen, a male, is: 4 13/16 inches long; 3 7/8 inches wide; 2 1/8 inches high.

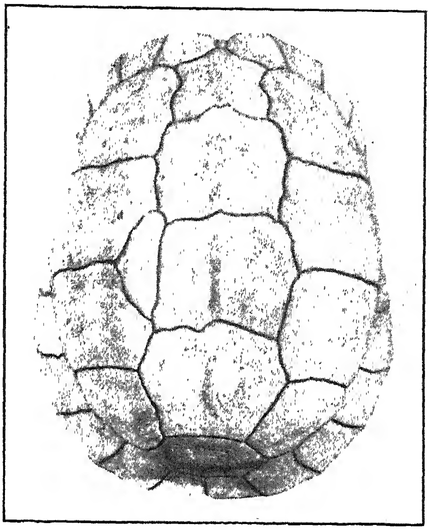


FIG. 1. CARAPACE OF COMMON BOX TURTLE MINUS SCUTE PLATES.

These measurements are within the usual ones for this type of *Cistudo*.

The second specimen (Fig. 2), which I found near Ellicott City, Howard County, is also of interest, due to the fact that there are two extra costal scute plates present. In this specimen the scute plates are strongly attached to the bony plates, thus preventing me from examining the outer surface of the bony plates.

Both of the fourth costal plates are divided into two plates, thus making five

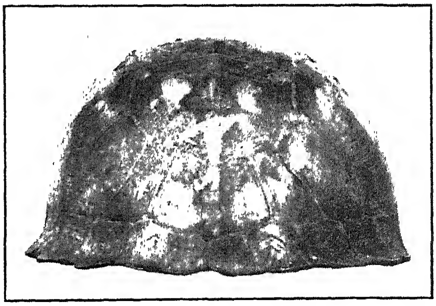


FIG. 2. POSTERIOR END OF CARAPACE OF COMMON BOX TURTLE SHOWING EXTRA PLATES (x,y).

costal plates on each side instead of four. The division of the left plate is exactly like that of the right plate. This division of the costal plate does not affect the usual arrangement of the marginal plates. Since the epidermal shields are still fastened to the bone I am unable to see if the bone has a deep groove at the junction of the abnormal scute plates as can be observed on the other specimen. From all observation the arrangement of the bony plates is not affected by the irregularities of the scute plates.

By studying the growth lines on the fourth and fifth costal and the fourth vertebral scute plates it is evident that the division of the fourth costal plate took place at a very early time in the development of the animal, because traces of the pointed lobe of the fourth vertebral scute plate which is partly inserted between the fourth and fifth costal scute plate can be traced by means of the growth lines until nearly the original vertebral scute plate is reached.

This Howard County specimen, a male, is: 4 5/8 inches long; 3 13/16 inches wide; 2 9/16 inches high.

In searching through the literature one finds very little mention made of abnormalities in the number and character of the scute plates of turtles. The following case is one which I thought would bear mentioning:

G. H. Parker[1] cites two cases of abnormalities in the scutes and bony plates of the sculptured tortoise (*Chelopus insculptus* Le C.). One specimen has the appearance of having been deformed, so that the outline of the shell appears to be twisted from left to right. On this specimen both the scute and bony plates are irregular. The other specimen which Parker says probably came from Maryland is regular in outline, but there is one less marginal scute plate on both sides of the posterior portion of the carapace. This can be interpreted, the author thinks, as due to the shortening of the carapace. This fact he illustrates by measurements taken from a number of tortoises of the same species.

Now to mention conditions as found in a few fossil turtles. Within the last month I have examined the plaston of several fossil turtles of Miocene age. There are several instances where extra plates are present, showing that the abnormality of extra plates is not confined to the recent animals.

Just what is the cause of the irregularities that present themselves in those cases which I have mentioned? The scute plates are derived from the ectoderm, while the bony plates come from the mesoderm. This course is decided upon in the egg long before the turtle is hatched. The evidence of growth is present on the scute plates by numerous fine concentric lines and the age of a turtle can be determined similarly to that of a tree. One of the explanations which presents itself for the extra plates is that the shell of the turtle has been exposed to some accident. The other explanation is that some irregularity took place in the development of the turtle before it was hatched. I will dispose of the former point first.

There is always the chance that the shell of a turtle might be injured by some accident, such as a rolling stone, being stepped upon by cattle or being hit by some vehicle like a lawn mower. I have seen cases where a large portion of the margin of the carapace was missing from an injury of this kind. The bony portion was slowly being replaced to its original form but leaving a pronounced scar. In other cases I have observed shells of turtles which have been injured high up on the carapace. In this case the scar ran across the growth

[1] G. H. Parker, "Correlated Abnormalities in the Scutes and Bony Plates of the Carapace of the Sculptured Tortoise," *Am. Naturalist*, 35: 17–24, 1901.

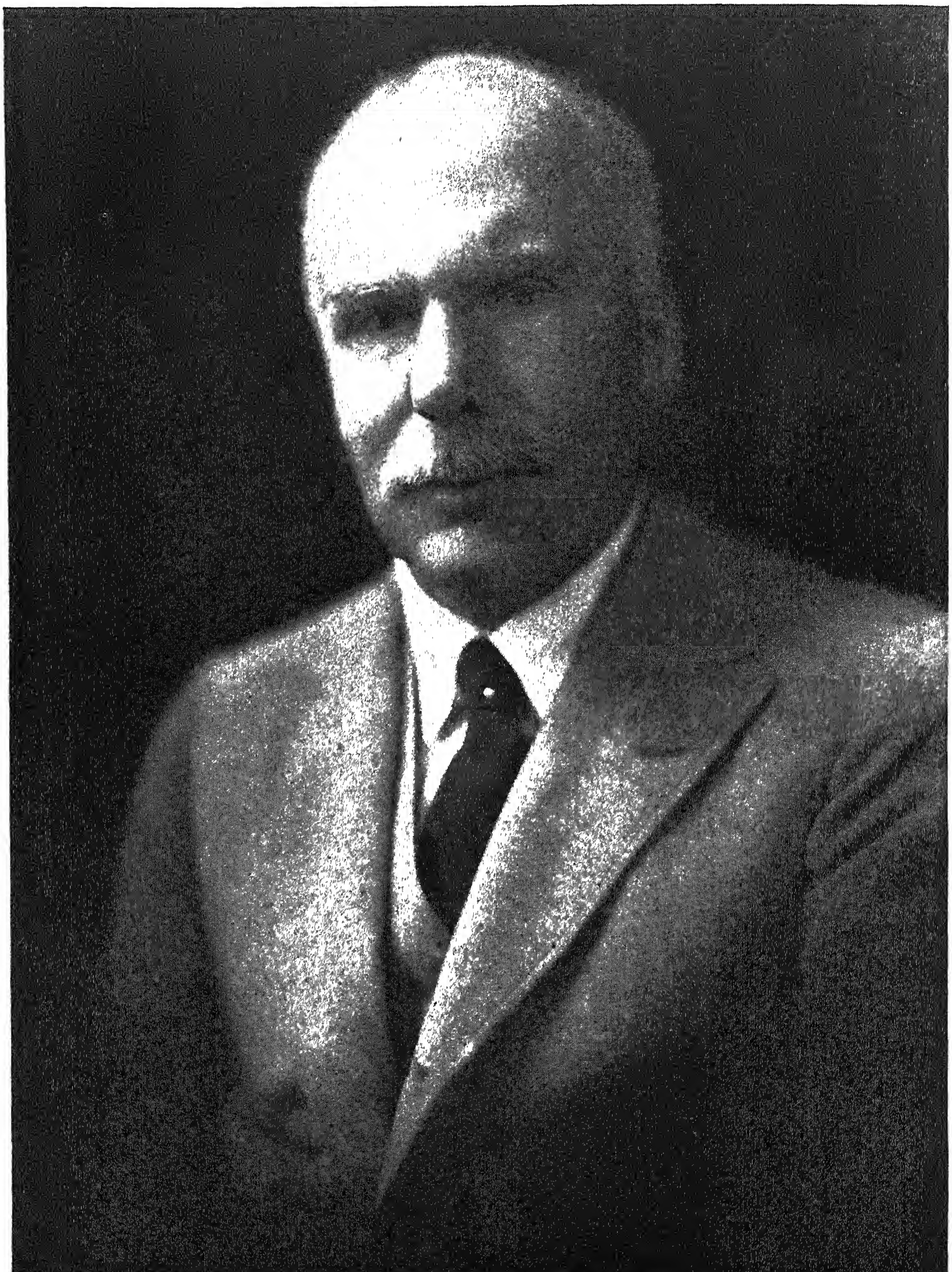
lines of the scute plates. In none of these cases was there evidence of the formation of new and differently shaped scute plates.

In both cases of *Cistudo carolina* there is no evidence at all of the animal's having been hurt sometime during its life. The growth lines of the odd plates are continuous from the first concentric lines to their last line. Where a sinus is found in the latter lines, this indentation can be traced backward until it disappears in the outline of the young scute plate. In these two cases the evidence of the extra plates can be traced to a very early stage in the development of the scutes. There are no breaks in the concentric arrangement of the growth lines.

This leaves the other question as the answer to the extra scute plates—that some irregularity took place in the development of the turtle before it was hatched. Just what this irregularity was is hard to say. It, however, only affected the growth of the ectoderm—that I am sure of in the specimen from Calvert County. Whether or not the mesoderm was affected as well as the ectoderm in the development of the specimen from Howard County, I can not say, but I feel sure that it was not.

Just what was the factor which brought about a change in the development of the ectoderm so that in some instances there appears a greater number of scute plates than is customary? If this difference only occurred in the development of a single egg we would call it a freak in the line of turtle history. But if the turtle continues to show more cases in which it grows additional plates we can term it evolution. Which is the truth in this case, time alone can tell. If it is evolution, time has taken thousands of years to prove it, for we have turtles in the geologic records from Upper Triassic to the recent. Most of these early turtles were much larger than the present-day ones, but the arrangement of their scute and bony plates is the same as that of their living descendants; with those exceptions where we find extra plates.

It is always interesting to speculate when dealing with evolution, but one should not let his mind wander from the plain facts too far or else he will reach an erroneous explanation. Thus I will leave the question open for others to decide for themselves—if they so wish—as to whether these two cases I have described are just freaks or steps in a line of evolution.



DR. FRANK R. LILLIE

PROFESSOR OF EMBRYOLOGY AND DEAN OF THE DIVISION OF BIOLOGY AT THE UNIVERSITY OF CHICAGO, WHO WAS ELECTED PRESIDENT OF THE NATIONAL ACADEMY OF SCIENCES TO SUCCEED DR. W. W. CAMPBELL, OF THE LICK OBSERVATORY. DR. LILLIE WAS ALSO ELECTED CHAIRMAN OF THE NATIONAL RESEARCH COUNCIL.

THE PROGRESS OF SCIENCE

THE ANNUAL MEETING OF THE NATIONAL ACADEMY OF SCIENCES

THE National Academy of Sciences was created by a special Act of Congress, approved by Abraham Lincoln on March 3, 1863. It was organized for two purposes—to encourage the development of science by honoring men who have contributed to knowledge by original research work, and to advise the Government on problems in science. As stated in the Charter "the academy shall, whenever called upon by any Department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expenses of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose; but the academy shall receive no compensation whatever for any services to the Government of the United States." The stipulation regarding compensation was wisely inserted to free the academy from any pressure which might be exerted on a paid agent and from criticisms arising therefrom. The organization meeting of the academy was held on April 22, 1863, and the first annual meeting on January 4 to 9, 1864. At this meeting 16 scientific papers were presented; in addition six different committees submitted reports on subjects on which several government departments had requested information and advice. These special committee reports were printed in the annual report of the academy for 1863 and cover 102 pages of the 118 pages of the report.

The seventy-second annual meeting of the academy was held on April 22, 23 and 24 at the academy building in Washington, D. C., with 113 academy members and one foreign associate in attendance. The scientific sessions were well attended and the scientific papers aroused interest and discussion. The distribution of the papers among the different fields of science was the following: Mathematics, 3; astronomy, 5; physics, 14; engineering, 1; chemistry, 3; geology, 1; geodesy, 1; botany, 6; zoology, 5; physiology, 3; pathology, 4; anthropology, 4; psychology, 3; biographical memoirs, 3. Academy members presented 37 papers; 18 papers were given by scientists introduced by academy members; and one paper was read by invitation. As a rule papers before the academy contain first announcements of the results of scientific research work. Summary statements of the scientific work of an organization or group are not customary; there are few invited papers; and rarely is a symposium held to consider a special problem on which information has been requested by the government. This attitude of the academy toward its scientific program has been adhered to since its first meeting and is reflected in the qualifications expected of a candidate for election; first and foremost he shall have contributed by original research work to the advancement of knowledge in his own field.

The Monday evening public lecture was given by Dr. Frank B. Jewett, vice-president of the American Telephone and Telegraph Company, on "Electrical Communications, Past, Present, and Future." Approximately 400 people were present at this extremely interesting address. At the scientific sessions the average attendance was approximately 500, both morning and afternoon.

On Tuesday afternoon academy members were invited by J. Edgar Hoover, director of investigation, to visit and inspect the Division of Identification of the Bureau of Investigation of the Department of Justice. The 50 or more members and guests who accepted

DR. DUNHAM JACKSON
PROFESSOR OF MATHEMATICS,
UNIVERSITY OF MINNESOTA.

DR. JEROME C. HUNSAKER
PROFESSOR OF AERODYNAMICS,
MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

DR. JOHN H. VAN VLECK
PROFESSOR OF PHYSICS,
UNIVERSITY OF MINNESOTA.

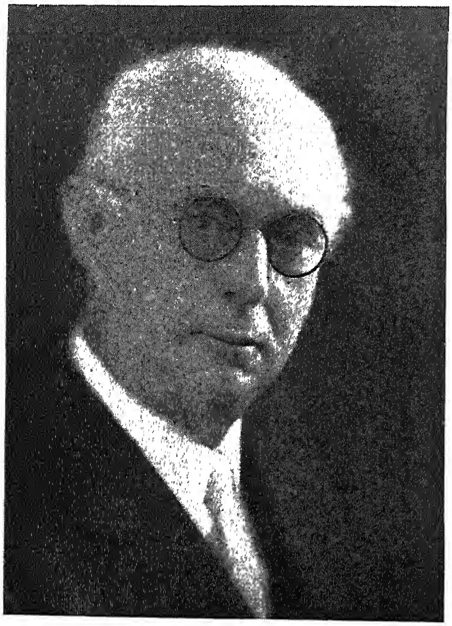
DR. HARVEY FLETCHER
ACOUSTICAL RESEARCH DIRECTOR,
BELL TELEPHONE LABORATORIES.

DR. HAROLD C. UREY
PROFESSOR OF CHEMISTRY,
COLUMBIA UNIVERSITY

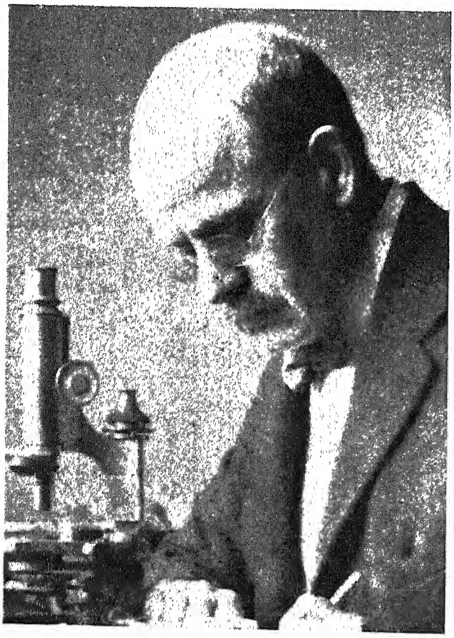
DR. NORMAN L. BOWEN
PETROLOGIST, GEOPHYSICAL LABORATORY,
CARNEGIE INSTITUTION OF WASHINGTON.

DR. ROSS AIKEN GORTNER
PROFESSOR OF BIOCHEMISTRY,
UNIVERSITY OF MINNESOTA.

DR. CHESTER R. LONGWELL
PROFESSOR OF GEOLOGY,
YALE UNIVERSITY.



DR. GEORGE ELLETT COGHILL
PROFESSOR OF COMPARATIVE ANATOMY,
WISTAR INSTITUTE OF ANATOMY, PHILADELPHIA.



DR. CHARLES M. CHILD
PROFESSOR OF ZOOLOGY,
UNIVERSITY OF CHICAGO.

the invitation were shown the methods employed in the identification of criminals by means of finger prints and other records. The exhibition was most interesting and gave members an insight into the functions and efficiency of this arm of the government.

At the annual dinner on Tuesday evening President Campbell delivered, at the request of the local committee and of the council, a brief address on the functions of the academy, as stated in its Congressional Charter, and of the significance of the contributions of science to human welfare. His address concluded with the significant sentence:

> I think we are all in accord with the thesis that the vast body of known truth about our surroundings, as revealed by the ways and the means of the physical and biological sciences, is incomparably more wonderful and inspiring than the fiction of the most lively imagination and, being idealistic and non-materialistic in character, is of the imperishable treasures of the human race.

This was followed by the presentation of four medals: *the Agassiz Medal* to Haakon Hasberg Gran, of the University of Oslo; *the Henry Draper Medal* to John Stanley Plaskett, director of the Dominion Astrophysical Observatory; *the Daniel Giraud Elliot Medal and Honorarium of $200, for 1932*, to James Paul Chapin, of the American Museum of Natural History; *the Public Welfare Medal of the Marcellus Hartley Fund* to August Vollmer, member of the staff of the Department of Political Science, University of California.

At the business meeting held on Wednesday, April 24, the following officers were elected:

President: Frank R. Lillie, professor of embryology and dean of the Division of Biology at the University of Chicago, for a period of four years, commencing July 1, 1935.

Home Secretary: Fred. E. Wright, petrologist, Geophysical Laboratory, Carnegie Institution of Washington, reelected for a period of four years, commencing July 1, 1935.

New Members of the Council of the Academy: Ross G. Harrison, of Yale University, and Henry Norris Russell, of Princeton University, reelected for a term of three years, commencing July 1, 1935.

New Foreign Associates: John Scott Haldane, New College, Oxford University, Oxford, England, and Jules Bordet, Pasteur Institute, Brussels, Belgium.

Photographs of the fourteen new members accompany this article.

At the first general session of the academy on April 22, President Campbell read the following letter from the President of the United States:

As you and your eminent colleagues meet in the seventy-second annual assembly of the National Academy of Sciences, I bid you warm welcome to Washington, and express my cordial wish for the greater development and usefulness of the Academy.

The country has every reason to be proud of the record of its scientific men and engineers. In astronomy, medicine, physics, chemistry, geology, and other sciences, and in the progress of engineering in all its branches, the contributions of America have been and still are outstanding in a friendly world rivalry.

It is a matter for thankfulness that among the many sources of world distrust and jealousies, science preserves an ideal of purity, truthfulness and mutual good will toward all nations. Not only do cooperative international scientific projects flourish, but the publications of scientists are received at face value in all lands, even though they be politically at variance.

The National Academy's charter provides that the Academy shall be ready at all times to give advice when called upon by any branch of Government. This privilege has been availed of by Government on many occasions. One of the most notable was during the great war, when the National Research Council was established by the Academy at President Wilson's call to mobilize the scientific learning and ability of the country to aid in that great struggle.

I take this opportunity to thank the Academy for the advice and assistance it has given the administration during the past two years, particularly where problems pertaining to the scientific policies of the Government have arisen.

With renewed congratulations and best wishes, I remain

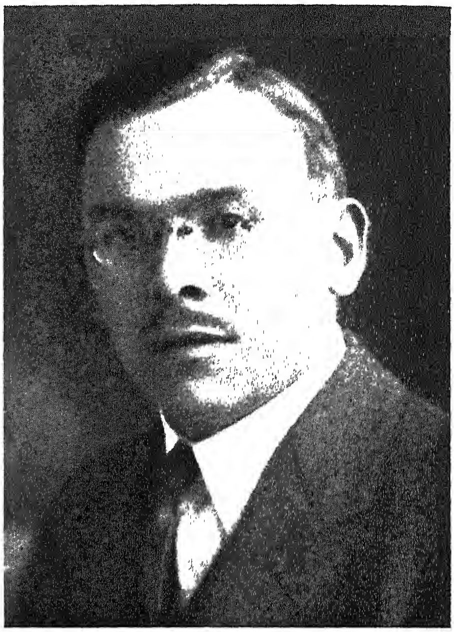
Very sincerely yours,

(Signed) FRANKLIN D. ROOSEVELT

DR. MERRITT L. FERNALD
PROFESSOR OF NATURAL HISTORY,
HARVARD UNIVERSITY.

DR. JAMES EWING
PROFESSOR OF ONCOLOGY,
CORNELL UNIVERSITY MEDICAL COLLEGE.

DR. WALTER S. HUNTER
PROFESSOR OF GENETIC PSYCHOLOGY,
CLARK UNIVERSITY.



DR. EARNEST A. HOOTON
PROFESSOR OF ANTHROPOLOGY,
HARVARD UNIVERSITY.

To this letter President Campbell replied as follows:

I have the great pleasure of acknowledging the receipt of your esteemed communication of to-day which extends to the members of the National Academy of Sciences a warm welcome to Washington for the holding of the Academy's Annual Meeting of 1935, and expresses your cordial wish for the greater development and usefulness of the Academy.

Your letter was read to the members of the Academy this afternoon at the opening of the first general assembly of this week's meeting, and I was requested and instructed to convey to you an expression of the Academy's deep appreciation of your thoughtful and courteous messages.

I am also requested to assure you that the members of the Academy are happy in their obligation and privilege of advising the Government of the United States on subjects within the domain of the physical and the biological sciences, whenever called upon by any branch or department of the Government for such service, under the wise provision of the Academy's Congressional Charter that "the Academy shall receive no compensation whatever for any services to the Government."

I have the honor to remain, Sir,
Yours respectfully,
(Signed) W. W. CAMPBELL, *President*

The present membership of the academy is 289 with a membership limit of 300; there are 44 foreign associates with a limit of 50.

The autumn meeting of the academy will be held this year on November 18, 19 and 20 at the University of Virginia at Charlottesville, Virginia. This meeting will be the first one of the academy to be held in the southeastern section of the United States.

F. E. WRIGHT,
Home Secretary

THE MINNEAPOLIS MEETING OF THE AMERICAN ASSOCIATION

THE ninety-sixth meeting of the American Association for the Advancement of Science is to be held in Minneapolis from June 24 to 29 inclusive. The University of Minnesota is host, as for the two previous Minneapolis meetings, and this year welcomes the Association to a new campus which is admirably

adapted for a successful meeting. Arrangements have been made for joint sessions and for exchange of privileges with the Minnesota State Medical Association which meets in the Minneapolis Municipal Auditorium from June 24 to 26. General headquarters are located in the Northrop Auditorium on the Minneapolis campus of the university. Hotel headquarters are located in the Hotel Nicollet.

In addition to the usual scientific papers in various fields the program of the meeting seeks to show what science has to offer towards the solution of present problems, especially in the Northwest. A strong group of speakers has been secured for the general sessions.

The Minneapolis meeting will open on Monday morning with registration at the Northrop Auditorium on the University of Minneapolis campus. The opening general session that evening is a joint meeting with the Minnesota State Medical Association, at which the address on "Diseases of the Blood" will be given by Dr. W. P. Murphy, of Boston, whose work on anemia brought him the Nobel prize in medicine. Tuesday evening the general session is devoted to the Maiben lecture. The speaker is Dr. Richard P. Strong, of Harvard University Medical School, and the topic, "The Importance of Ecology in Tropical Disease," will be illustrated with material from his recent expedition to Africa. Following this lecture an informal reception to visiting scientists will be tendered by President and Mrs. L. D. Coffman of the university. On Wednesday evening Dr. Isaiah Bowman, president-elect of the Johns Hopkins University, is to speak on "The Land of Your Possession." Thursday evening Dr. Wm. F. G. Swann, director of the Bartol Research Foundation, will address the general session on "The Nature of Cosmic Rays." The Friday evening general session will be addressed by Dr. Philip Fox, director of the Adler Planetarium and Astronomical Museum in Chicago, on the subject "The Scale of the Universe."

Of especial significance is the symposium on Conservation to be held Thursday morning. Through generous cooperation of the university several distinguished speakers have been secured to present to visiting scientists and to students of the University Summer School, then to be in session, the views of scientific workers on the problems of conservation and their solution.

The Minnesota State Medical Association will show a large series of demonstrations and exhibits to which members of the A. A. A. S. are admitted. Departments of the university have planned many exhibits and will keep open house throughout the week. The programs of sections and societies vary greatly but in many stress has been laid on symposia and joint sessions held in the forenoons, with field trips announced for the afternoons. Other field trips fill the entire day and a few extend over even longer periods, giving rich choice to visitors for contact with the unique features of the region. All persons are at least superficially familiar with the attractive environment of the Twin Cities, Minneapolis and St. Paul, and with the great vacation areas of lakes, streams and forest wilderness in the northern half of the state. These afford unrivalled opportunities for scientific study and vacationing. Those who seek information on the state will find it well described and illustrated in a recent number of the *National Geographic Magazine*.

The first Minneapolis meeting in August, 1883, was regarded as a daring venture into the Northwest, but the record of its proceedings forms an impressive annual volume in the early publications of the association. The record of the second meeting, held in December, 1910, showed an equally extensive and

varied scientific program. Details already reported give promise of similar variety and value in the program for this meeting. The work of secretaries of sections and affiliated societies has brought together material in diverse fields sure to interest members and visitors. The local committee, of which Professor D. E. Minnich is chairman and Professor D. G. Paterson, secretary, has done much to insure the success of the meetings, in which they have been aided by some forty associates from the university and the city of Minneapolis.

Henry B. Ward,
Permanent Secretary

THE STRATOSPHERE BALLOON FLIGHT

The 1935 stratosphere flight in *Explorer II,* like that of 1934 in *Explorer I,* will be made under the joint auspices of the National Geographic Society and the U. S. Army Air Corps. The ascent will be made from the Stratocamp, a cliff-encircled basin in the Black Hills, 12 miles southwest of Rapid City, South Dakota. The site of the Stratocamp was chosen both for the 1934 and 1935 flights because of the excellent facilities afforded for the project. The location toward the western edge of the Great Plains region provides a large expanse of unforested country to the southeast—the direction of drift—in which to land. The camp, protected on three sides by cliffs rising from 350 to 500 feet, and on the fourth side by hills equally high, furnishes an ideal place for the inflation of the huge balloon.

Balloon, gondola, and instruments will be assembled at the Stratocamp, ready for the flight, by June 1. The ascent will be made during the first weather favorable for stratosphere flying after that date. The weather conditions must be such as to promise freedom from clouds and excellent visibility over a large area to the east and south.

The purpose in sending this expedition into the stratosphere is to carry out measurements which can not be made through the blanket of the earth's atmosphere, which is equivalent to a layer of water thirty feet thick. A very large balloon is being used because in no other way can the instruments, which are necessarily heavy, be lifted to the desired height.

The investigations will include:

(1) Measurements of temperature and barometric pressure changes, from the earth to the highest point to be reached by the balloon; (2) Collection of samples of stratosphere air for analysis; (3) Cosmic ray studies, including the number and direction of the rays at various altitudes; (4) Spectrographic studies of sunlight and skylight, and the distribution of the ozone layer; (5) Sky brightness, sun brightness and earth brightness; (6) Wind direction and velocity studies; (7) Additional checks on measurements of altitude made by barometers; (8) Studies of the changes in the electrical conductivity in the air with increasing altitude; (9) Studies of high-frequency radio signals sent from the stratosphere and received on the ground; (10) Collection of spores in the stratosphere.

Captain Albert W. Stevens, U. S. Army Air Corps, will be in command of the flight and will have charge of the scientific program and instruments. Captain Orvil A. Anderson, U. S. Army Air Corps, will pilot the balloon. Captain Randolph P. Williams, U. S. Army Air Corps, will be in charge of ground operations and will stand by as alternate pilot.

The balloon to be used in the stratosphere flight, *Explorer II,* was designed and built by the Goodyear Zeppelin Corporation, in Akron, Ohio. It is larger than the *Explorer I,* which, at the time of its manufacture, was the largest balloon ever constructed. When fully inflated the *Explorer II* will be a sphere

Photograph by National Geographic Society—Army Air Corps Stratosphere Flight

PARTICIPANTS IN THE STRATOSPHERE FLIGHT

LEFT TO RIGHT, CAPTAIN ORVIL A. ANDERSON, PILOT; AND CAPTAIN ALBERT W. STEVENS IN COMMAND OF THE FLIGHT AND IN CHARGE OF ITS SCIENTIFIC ACTIVITIES; AND CAPTAIN RANDOLPH P. WILLIAMS IN CHARGE OF GROUND ARRANGEMENTS AND INFLATION OF THE BALLOON. THE THREE OFFICERS ARE STANDING IN FRONT OF THE 9-FOOT METAL BALL IN WHICH CAPTAIN ANDERSON AND CAPTAIN STEVENS WILL BE SEALED AIRTIGHT WHILE IN THE STRATOSPHERE. TO THE RIGHT OF CAPTAIN WILLIAMS IS AN INSTRUMENT WHICH WILL RECORD THE ELECTRICAL CONDUCTIVITY OF THE AIR. THE FLIGHT, UNDER THE AUSPICES OF THE NATIONAL GEOGRAPHIC SOCIETY AND THE U. S. ARMY AIR CORPS, WILL BE MADE FROM THE "STRATOCAMP" 12 MILES SOUTHWEST OF RAPID CITY, SOUTH DAKOTA, AS SOON AFTER JUNE 1 AS THE WEATHER PERMITS.

192 feet in diameter, 13 feet greater in diameter than *Explorer I.* The cubic capacity is 3,700,000 cubic feet, as against 3,000,000 cubic feet for *Explorer I.*

The bottom fabric of the bag (the portion in which tears occurred last summer) is made of the same weight as the main fabric of the balloon: three ounces to the square yard before the rubber was

applied; 5.3 ounces afterward. In *Explorer I* the bottom fabric was of two-ounce weight before it was rubberized. The top of the balloon bag is made of four-ounce cloth before the application of rubber.

The *Explorer II* will be inflated with helium; hydrogen was used last year. The primary reason for the change to the more expensive gas is to eliminate all possibility of explosion. Helium will not burn and remains inert when mixed with any proportion of air. Hydrogen, on the other hand, burns readily and forms an explosive mixture with air.

Since a given volume of helium will lift only 92 per cent. of the weight which can be lifted by the same volume of hydrogen it became necessary to give *Explorer II* a considerably greater volume than that of *Explorer I,* in order to reach the same ceiling.

When the balloon leaves the ground it will contain only about 300,000 cubic feet of helium, approximately eight per cent. of its capacity. Since the gas expands rapidly as it rises above the earth, it would be wasteful to start with more. The bag will become full and take on its spherical shape approximately 12 miles above the earth. Above this point the expanding gas will escape from the bottom of the bag through four appendixes or inverted chimneys of fabric.

The exact height to which the balloon will rise will depend upon a number of factors: the temperature and barometric pressures at time of take-off; the degree of extra expansion due to superheat caused by the shining of the sun on the bag; the total load of the balloon; the relationship between the weight of the ballast that can be discarded and that which must be retained for the down trip; and the amount of gas valved away in order to keep the balloon on the same level for certain periods. It can be estimated very roughly that the balloon should rise to an altitude above 70,000 feet or 13¼ miles. At this height the atmosphere will be only about 1/23 of the density of the atmosphere at sea-level. In other words, 22/23 of the total atmosphere will lie below the level of the balloon, and only 1/23 above it.

The balloon and its ropes weigh 6,350 pounds. The gondola, instruments, equipment, and men weigh 3,750 pounds. More than 8,000 pounds of lead-shot ballast will be carried. The entire weight of balloon, gondola, and load when it leaves the ground will be approximately nine tons. The balloonists will make their ascent into the stratosphere in an air-tight, metal ball which will be suspended beneath the balloon. This gondola or cabin is made of Dowmetal, a magnesium alloy lighter than aluminum. The metal shell is 3/16 of an inch thick, 9 feet in diameter and weighs 638 pounds. The gondola is provided with two elliptical man holes, slightly larger than those of 1934, and six observation portholes, covered with double thicknesses of glass. Midway between the man holes is a hinged arm, 14 feet long, which carries a propeller fan at the outer end. This fan, controlled from within the gondola and driven by a storage battery, will cause the gondola and balloon to turn slowly, thus pointing the instruments in any desired direction.

LYMAN J. BRIGGS

DIRECTOR, NATIONAL BUREAU OF STANDARDS; CHAIRMAN, SCIENTIFIC ADVISORY COMMITTEE OF THE NATIONAL GEOGRAPHIC SOCIETY—ARMY AIR CORPS STRATOSPHERE EXPEDITION

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